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# THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 8 MAY, 1958 NUMBER 3

*COMPLETE DENTURES*
*REMOVABLE PARTIAL DENTURES*
*FIXED PARTIAL DENTURES*
*OPERATIVE DENTISTRY*

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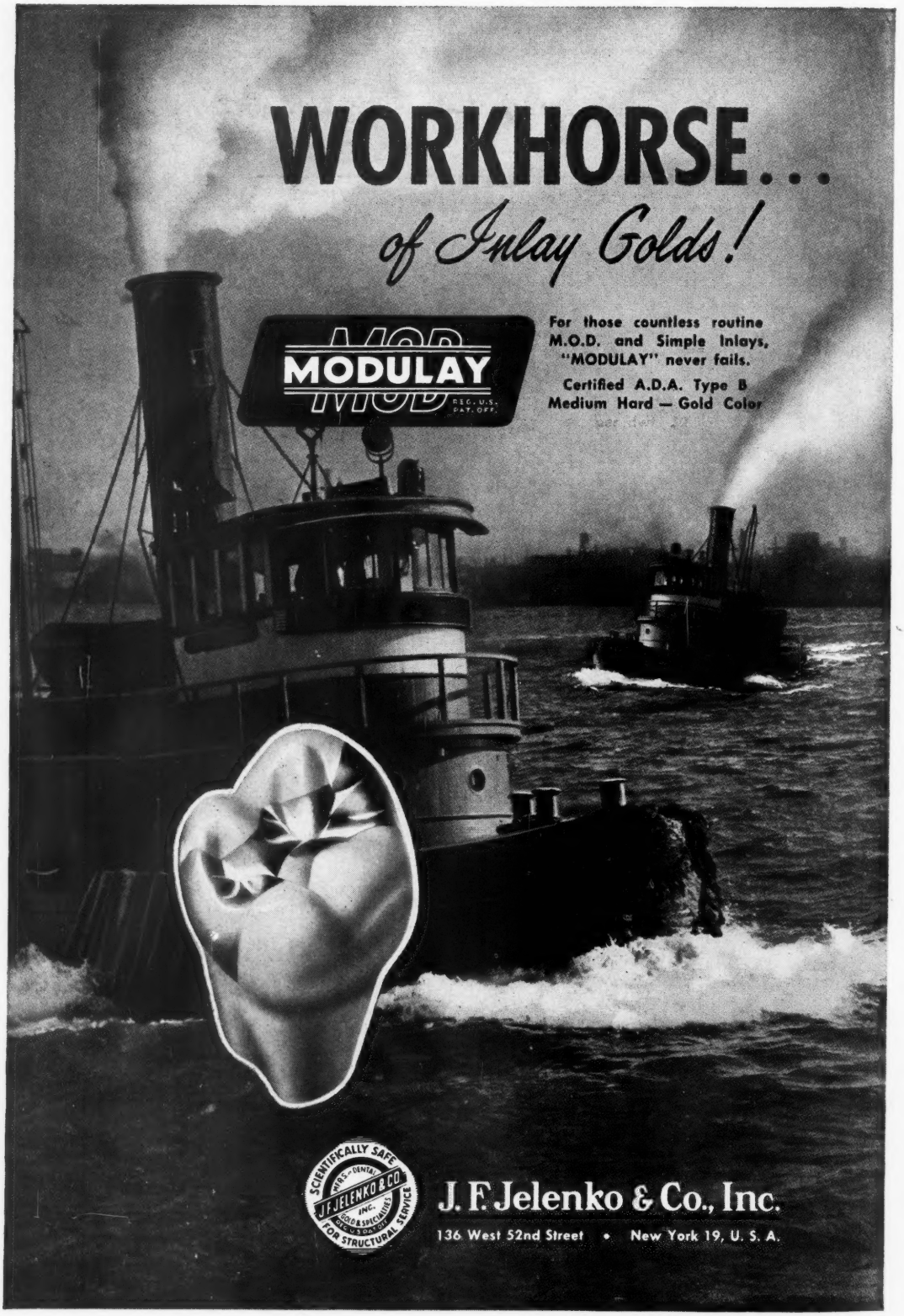
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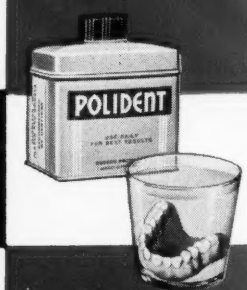


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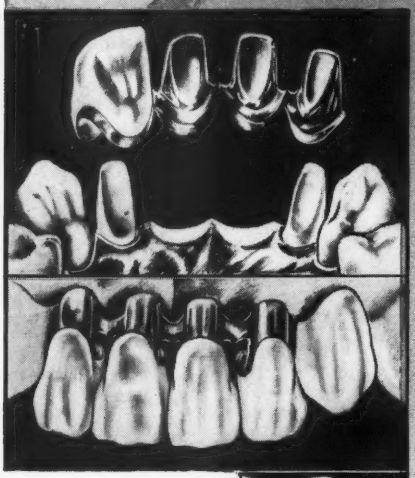

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## THROUGH THE EYES OF THE EDITOR

Irving R. Hardy and Krishan K. Kapur discuss and classify the various factors involved in the retention of dentures. They have added psychologic and surgical factors to those which have been traditional. There can be little doubt that these play an important part in the retention of dentures. They emphasize the importance of a border seal for the full use of atmospheric pressure as a retentive force. They consider this an advantage when severe dislodging forces are applied to the denture. They describe their techniques for creating a posterior palatal seal on both metal and plastic dentures.

Lawrence A. Weinberg discusses the relationship of positions of teeth to the denture base foundation. This is a most fundamental consideration, and it is one that seems to be ignored frequently, or it is not understood. He relates the arch form of the anterior teeth to the form of the edentulous arch and bases his discussion primarily upon the leverages produced. A similar approach is used to solve the problem of posterior tooth position. The principle of having the artificial tooth in exactly the same position as that of the natural tooth it replaces is fundamentally sound. It is the only way the tissues of the face (skin and muscles) can be properly supported. Likewise, it is the only way the soft tissues which surround the dentures can assist in their stabilization. The force produced by the soft tissues of the cheeks, lips, and tongue (which helped to align the natural teeth when they erupted) cannot be disregarded when the arch form of artificial teeth is determined. The rule he suggests for posterior tooth placement may be open to question because of the varying interpretations of it. If the teeth have been out a very short time, the rule should be adequate, but if the ridge was narrow, it would be better to have the buccal cusp of the lower molar bisected by a perpendicular erected from the crest of the lower ridge. If the ridge has been completely resorbed, the tooth should be placed so its lingual surface does not extend lingual to the mylohyoid ridge. As in all phases of prosthodontics, good judgment is required in the application of any rules.

C. E. Adam describes his technique for making a duplicate of an existing denture. The procedure is ingenious and workable, but it is possible that the shrinkage of the wax and of the hydrocolloid duplicating material may cause some errors in the duplicate dentures. These would not be too difficult to correct by the usual methods.

G. A. Lammie and R. Storer discuss the use of resilient plastics in dentures. They describe several situations where these soft resins would be helpful and give consideration to the physical properties which they believe these materials should possess. They compare the various materials that are available and point out their merits and deficiencies. They report their clinical experiences with these materials as well as laboratory tests they have made. The results seem to indicate that there are unsolved problems relating to the use of these materials, and it is to be hoped that the manufacturers will soon be able to overcome these difficulties.

Leroy E. Knowles discusses the biomechanics of removable and fixed prosthesis. He urges that the dentist make an adequate diagnosis before he plans the treatment and that he plan the construction phases completely before he calls upon his auxiliary assistants. He discusses the various elements of the restorations that have a bearing on the end result of the treatment and sets up certain specifications for the component parts of these appliances.

Albert Seiden discusses the functions, design, and location of occlusal rests for removable partial dentures. This extremely important part of the design of partial dentures and of mouth preparation deserves more attention than it has been given in the past. Specifications for occlusal rests and rest seats are set up, and techniques for developing them are described. It is interesting to note the variations in rest seat preparations which make sure that occlusal forces will be directed along the long axis of the tooth and at the same time prevent the drifting of abutment teeth. This phase of design of partial dentures is more important, in many instances, than the location of clasp arms on a tooth.

Louis Blatterfein classifies partial dentures which need relining into seven groups according to their design and according to the corrections they may require and discusses five basic changes which make relining necessary. His analysis of the problems is sound, and it emphasizes the importance of an adequate diagnosis before relining procedures are instituted. He describes practical and logical procedures for relining each "group" of partial dentures. It is obvious, but frequently overlooked, that relining or rebasing involves more than simply adding base material to partial dentures. The procedures must be varied according to the changes that have occurred. The method of treatment should vary with the design of the denture and the situation to be corrected.

Thomas D. Gilson discusses his concept of the correction of the occlusion of natural teeth and suggests some new terms for indicating certain jaw and tooth relationships. It seems that agreement should result (eventually) upon terms to represent definite jaw positions and tooth relationships. If we can recognize and agree upon centric jaw position or relation as one definite jaw position that can be located, and if we can agree that the jaw can move to other positions, we should be able to label and understand centric relation and eccentric relation. If we can recognize and agree that teeth (either natural or artificial, or anatomic or nonanatomic) can occlude or come together with an ideal interrelationship between their occluding surfaces, and if we can agree that they can contact each other in *other than* the ideal interocclusal relationship, we should be able to agree that terms should be available to designate these tooth-to-tooth relationships. If we can recognize and agree that the teeth may occlude in their ideal tooth-to-tooth relationships while the jaws are in one of the many eccentric relations, we should agree that a term or terms should be available for designating this specific set of circumstances. Other possible *combinations* of tooth relationships and jaw relationships suggest themselves. Terms should be available to designate these specific conditions. Gilson has made an effort in this direction and, while the terms he has suggested may not be the ones which will have eventual approval, he has suggested a way toward what is likely to be a very simple solution to a knotty problem. The problem is not one of concepts, but rather it is a problem of having the other person understand *exactly* what one is saying when he talks or writes about occlusion.

Peter B. Christensen describes his techniques for making accurate casts and jaw relation records. He uses acrylic resin clutches and a rubber base impression material for attaching a kinematic face-bow to natural teeth. There seem to be definite advantages in this method of fixation. The interocclusal records should be accurate because occlusal interferences are eliminated by the use of a central bearing point and the potential distortion of wax interocclusal records is avoided.

I. Franklin Miller discusses the use of full coverage attachments to abutments for fixed restorations. He describes his system of tooth preparation which is based upon an orderly sequence of operations. Obviously, a planned sequence of operations can eliminate unnecessary motions and, by this means, operating time will be reduced. He makes full use of indirect procedures which require the minimum of the patient's time. He waxes his crowns over a gold matrix. The gold matrix must be very accurately adapted. This procedure

has certain technical advantages over patterns made entirely of wax, but there may be some disadvantages also. The gold matrix procedure reminds one of the gold inlays made before the advent of the modern casting techniques, but now it is combined with accurate casting methods.

Carlos B. Harmon discusses the form and materials used in pontics. He feels that this phase of fixed prosthodontics has not received the attention it deserves. He urges the use of glazed porcelain where a pontic touches the mucous membrane and suggests some pontic forms that would seem to carry out his objectives.

John Kuratli describes a simple and practical method for building up badly broken down teeth for use as fixed partial denture abutments. The procedure can be used also to save individual teeth and for abutments for removable appliances. Obviously, the technique carries with it the obligations to eliminate all dental caries and to use other common precautions against recurring decay.

W. J. Simon discusses the role of operative dentistry in the foreseeable future. He recognizes it as a preventive measure, and if it is properly accomplished, it can be just that. Not all dental caries can be eliminated at once, even if a "specific" could be devised for it. Current information indicates that the incidence of dental caries can be greatly reduced by the application of such measures as fluoridation of public water supplies and other measures. However, even if these measures were 100 per cent effective, it will take a generation for their full impact to be felt. Meanwhile, the other technical improvements and a greater sense of responsibility for prevention by operative dentists will tend to hasten the day when dental caries will not be a serious problem. Continuing research in all phases of the problem is essential.

G. T. Charbeneau and F. A. Peyton report their experiments on the effects of cavity instrumentation on the adaptation of gold castings and silver amalgam. Their controls seem to have been carefully worked out so the results should be valid. They found that various cutting instruments produced various degrees of cavity wall roughness, but most casting roughness was due to casting techniques rather than cavity preparation. The adaptation of silver amalgam was adequate so long as *careful* techniques were employed. This was to be expected.

Harold C. Kilpatrick discusses and compares some of the new high-speed engine equipment which is available. In order to conserve time in changing instruments, he suggests the use of dual engines or dual engine arms. This would give the dentist a wider range of engine speeds but it might make the dental office *appear* more ominous to patients than with less complicated-appearing equipment.

G. E. Myers discusses the principles involved in the formation of electroformed dies in rubber base impressions and describes his technique for making removable silverplated dies. The procedure is simple enough to be practical and is efficient provided it is properly carried out and controlled. The electroformed dies have definite advantages over other materials used for this purpose.

Gerald D. Stibbs and Charles Schroeter describe the techniques for making the various models used at the University of Washington, School of Dentistry. The techniques are relatively simple and practical. The models are made in a large range of sizes.

Alex Fox describes his prosthetic treatment of an acquired cleft palate. The appliance and the technique of its construction are practical and sound. The increasing incidence of radical palatal surgery makes this an important prosthetic service.

*—Carl O. Boucher*

## *COMPLETE DENTURES*

# POSTERIOR BORDER SEAL—ITS RATIONALE AND IMPORTANCE

IRVING R. HARDY, D.M.D.,* AND KRISHAN K. KAPUR, B.D.S., M.S.**
*Tufts University School of Dental Medicine, Boston, Mass.*

THE RETENTION OF THE DENTURE is of utmost interest to the patient and a matter of great satisfaction to the dentist. It is difficult to consider stability and retention as separate entities because of the close dependency of the one upon the other. A lack of either property will influence the effectiveness of the other to a great extent. Although both are indispensable in the evaluation of a good denture, stability takes precedence over retention as the paramount prerequisite in denture construction.

Retention in a denture not only enhances its stability, but also it helps to meet the various psychologic problems encountered by the patient during the learning or the re-educating period. Such psychologic problems might include the fear, apprehension, and embarrassment caused by unsatisfactory denture retention. Thus, retention supplementing stability will achieve a finished denture which satisfies the physical, physiologic, and psychologic needs of the patient.

### THE FACTORS GOVERNING RETENTION

A review of the current literature on the subject of the physical factors which govern the retention of dentures leads one to believe that a great diversity of opinion still exists regarding this question. These factors have been summarized and are presented in Table I. The role of these physical factors controlling retention has been described by Cox,[1] Fry,[2] Howland,[3] Moses,[4] Page,[5] Pryor,[6] and many others. Particular emphasis has been placed on isolated physical factors that influence retention rather than taking into account the whole picture. Although there is a difference in opinion regarding the *relative* role of the physical factors, their contributions toward retention goes unchallenged and has been well established—with one important exception.

### ATMOSPHERIC PRESSURE

The influence of atmospheric pressure in the retention of the denture has been subjected to much criticism by the proponents of the mucostatic techniques.[7] This criticism has occurred mainly because of misuse of the technique in the early days.

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**Fellow in Prosthetic Dentistry.

The original idea of using atmospheric pressure as a means of retention was introduced by Ames[8] and the Greene brothers[9] in 1883. They recommended the use of functional denture borders as opposed to passive borders in the fabrication of complete dentures. Abuses during the early history of this concept in its incorrect and extreme usage were in the form of suction and vacuum chambers used as a means for the retention of dentures. Spectacular retention, obtained with excessive displacement of soft tissues, was temporary in nature and caused pathologic

TABLE I. FACTORS GOVERNING THE RETENTION OF DENTURES

| | |
|---|---|
| *Physical* | Adhesion |
| | Cohesion |
| | Interfacial surface tension |
| | Atmospheric pressure |
| *Physiologic* | Physical condition |
| | Degree of tissue tone |
| | Quality and quantity of saliva |
| | Condition of mucosa and submucosa |
| | Neuromuscular control |
| | Ridge characteristics |
| | Ridge relationship |
| *Psychologic* | Intelligence |
| | Expectation |
| | Apprehension or fear of embarrassment |
| | Gagging |
| *Mechanical* | Occlusion |
| | Leverage |
| | Contour of denture bases |
| *Surgical* | Implant dentures |
| | Ridge extension |

changes due to constant pressures on the soft tissues. These undesirable results caused the concept to lose favor. In 1920, Hall[10] revived interest in the use of atmospheric pressure as a retentive factor by interpreting and demonstrating the functional denture borders.

Retention and stability, derived from the forces of adhesion, cohesion, and the so-called interfacial surface tension, resist only the dislodging forces acting perpendicular to the denture and fail to resist the dislodgment of the dentures by horizontal forces and lateral torque. The dislodgment of the dentures by lateral torque and horizontal forces could be resisted by the retention provided by the partial vacuum which may be created as a result of denture border seal. The influence of an individual physical factor will vary under different physiologic conditions. Thus, retention afforded only by the good adaptation of the denture to the underlying stuctures may fail to suffice in patients who have thick ropy saliva or in those with dryness of the mouth (xerostomia). Therefore, it seems logical that judicious use of the various factors, including atmospheric pressure, should be made in denture construction. At the same time, one should not forget the well-chosen words of DeVan[11]: ". . . our task is not to try to maintain function, in scope, degree, and direction, as it had been prior to the mutilation, but rather to preserve what remains of the oral mechanism."

## THE RATIONALE OF BORDER SEAL AND POSTERIOR PALATAL SEAL

Often it is possible to obtain acceptable stability and retention by a perfectly adapted denture base through the forces of adhesion, cohesion, and interfacial surface tension. The addition of proper border seal transforms a base that has only adhesive retention into a very stable base which will resist tipping thrusts from all directions. This border seal is made possible by developing the proper width and the extension of the denture borders so that they fill the mucobuccal space and buccal pouch and make a seal against the cheeks. The border seal is obtained by tracing low-fusing stick modeling compound on the borders of the tray and by border molding section by section. The border seal is completed in the palatal region of the maxillary denture by developing the posterior palatal seal. Such a seal will create a partial vacuum that will not operate continuously, but one that will come into play only when horizontal or tipping thrusts tend to dislodge the denture and then only long enough to overcome the emergency. This partial vacuum is unlikely to operate long enough to do any damage to the supporting or border tissues. The retention of complete dentures may be accomplished more accurately and safely with a good appraisal of the biologic factors. Pendleton[12,13] has given excellent illustrations on the importance of, and the variations of, the minute anatomic structures of the jaws.

Excessive border seal, which is obtained by scoring the cast all around or by displacing the soft tissue,[14,15] should be condemned. Spectacular retention, so obtained, is temporary and causes the destruction of the supporting structures because of constant heavy pressure and the interference with the vascular supply.

The establishment of the distal length of the basal seat and the development of the posterior palatal seal is one of the most important steps in the construction of the maxillary denture. In addition to providing retention, the development of the posterior palatal seal on the denture has the following advantages: (1) it provides a close contact of the denture base with the mucous membrane which prevents food from getting under the denture; (2) it provides a firm contact of the denture base with the tissue, and this diminishes or eliminates gagging; (3) it supplies sunken distal borders which are less conspicuous to the tongue; and (4) it supplies a thick border to counteract denture warpage.

Hundreds of dentures have failed due to the improper establishment of the distal length, and secondly, to an improper post palatal seal. Both of these operations are as much the duty of the dentist as is the making of the impression. These operations cannot be done by the dental laboratory technicians, and no dentist should foist this responsibility on his technician. Skinner[16] has demonstrated the importance of the posterior palatal seal experimentally and stated that the most effective addition to increase in retention was the post dam. Any reduction in the posterior palatal seal produced a decrease in retention.

## TECHNIQUES

Many techniques for developing the posterior palatal seal have been described in the literature. They can be classified as functional, semifunctional, and empirical.

In the functional techniques, the final impression is border molded in the posterior palatal seal area with soft stick modeling compound or wax by sucking and bubbling movements performed by the patients.[17] Whereas, in semifunctional techniques, the border molding is done by the dentist. Terrell[18] comments, "In order to have a good post dam, it is not necessary to compress this tissue to a maximum as is often done by the post damming techniques, employing modeling compound."

In the empirical technique, the posterior palatal seal is developed on the cast by grooving the cast to the desired depth. With this technique, the dentist can make a check of the sufficiency of the posterior palatal seal and he can also gain an insight into the retention of the final product.

## METHODS USED TO DETERMINE IMPORTANT FACTORS

It is essential that the original impression be extended far enough distally to record the detail of all areas involved.

Having secured a proper impression, and having poured and trimmed the cast properly, a single thick pink baseplate is adapted carefully to the cast and extended into the border roll labially and buccally. A pink baseplate is used, since certain indelible pencil marks, subsequently to be made in the mouth, will transfer much more legibly to the light-colored baseplate than to a darker colored one. A hard wax occlusion rim is adapted to this base.

With the patient seated in the chair and the mouth open, the tissues at the junction of the soft and hard palate are partially dried with cotton. It is well to have the patient use an astringent mouthwash just before this is done in order to remove the stringy saliva which would interfere with a sharp marking. The patient is instructed to say "ah," and an indelible pencil mark is made at the point in the center of the palate anterior to which there is little or no movement of the soft tissue.

This "ah" line will, we think, invariably include the fovea palatini. The technique of establishing the distal length of the denture by using the fovea palatini as landmarks will often deprive the dentist of the use of several millimeters of posterior palatal seal area.

Having established the "ah" line, a *T* burnisher, which has been bent to have a similar angulation as a mouth mirror, is used to locate the pterygomaxillary (hamular) notches, and an indelible pencil is used to make a line 1.5 mm. distal to the notch (Figs. 1 and 2). These marks are then connected to the mark in the center line of the palate (Fig. 3), and the baseplate is inserted quickly into the mouth and then removed. It will be noted that the indelible markings have been transferred to the baseplate (Fig. 4)

The use of the *T* burnisher or mouth mirror (the *T* burnisher is a handier instrument) is especially necessary where there are no tuberosities. In mouths where the tuberosities are present, it is very easy to locate the hamular notches as they are directly behind the tuberosities. However, if the tuberosities are not present, as in the mouths of many people who have been denture wearers for years, it is very easy to mistake some small depression in the approximate area for the hamu-

lar notch, and many dentures have failed because of this misinterpretation. The use of an instrument as described will identify the notch unmistakably, for the instrument will drop into the notch and identify it without question.

The baseplate is trimmed to the transferred indelible pencil marking, and the occlusion rim is reinserted into the mouth (Fig. 5). If at any point the indelible

Fig. 1.

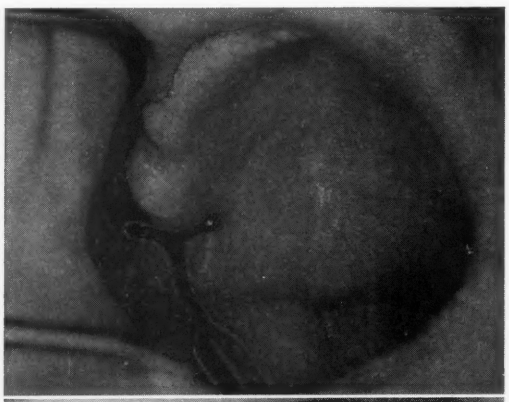


Fig. 2.

Fig. 3.

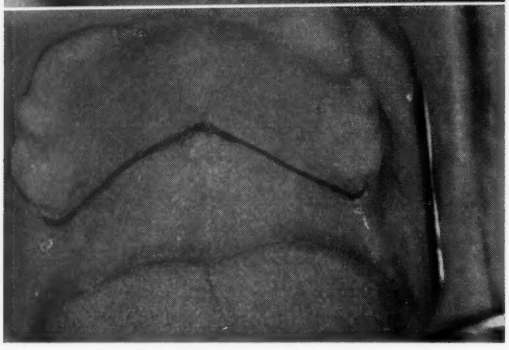


Fig. 1.—A *T* burnisher bent to a 45 degree angulation is used to locate the pterygomaxillary notch.

Fig. 2.—Indelible pencil marks are made in the mouth to indicate the posterior limits of the denture in the center line and in the pterygomaxillary regions.

Fig. 3.—The posterior limit line is completed by a line joining the three marks.

marking was indefinite and hence the trimming of the baseplate a little uncertain, this rechecking in the mouth and examination with the mouth mirror will reveal whether or not the baseplate has been trimmed properly.

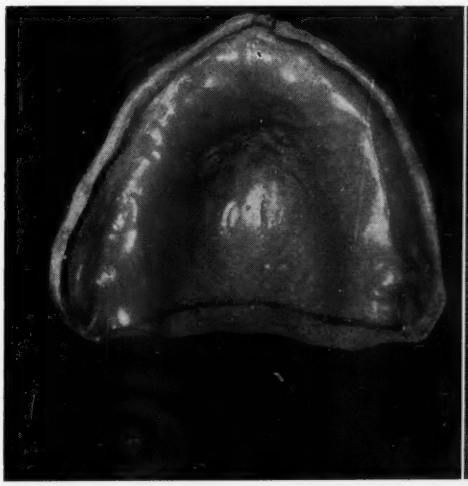


Fig. 4.

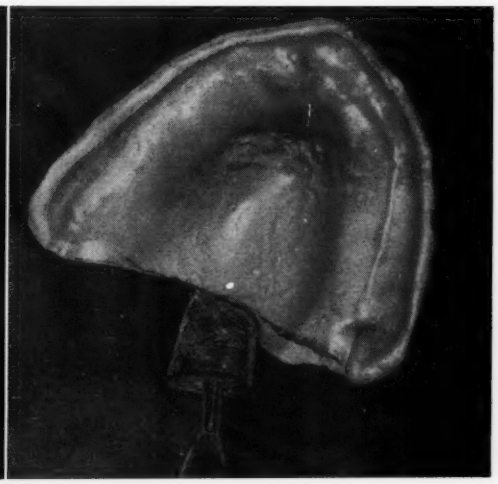
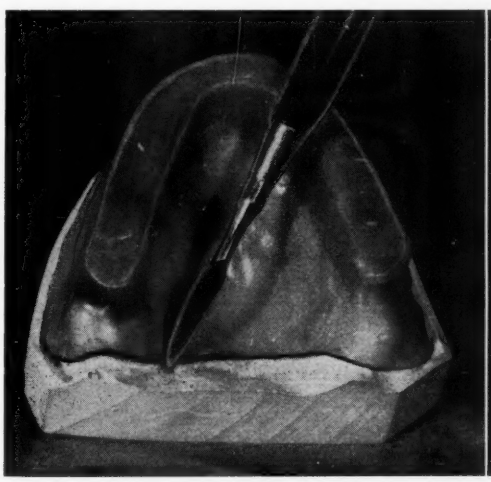


Fig. 5.

Fig. 4.—The posterior limit line is transferred from the mouth to the baseplate.
Fig. 5.—The baseplate is trimmed to the transferred indelible pencil line.



*A.*

*B.*

Fig. 6.—*A*, The posterior limit line is transferred onto the cast. *B*, The posterior limit line is scored in the cast to indicate the distal extent of the upper denture.

The occlusion rim is removed from the mouth, returned to the cast, and the cast is scored exactly at the distal margin of the baseplate (Fig. 6). This score mark on the cast will be transferred to the processed denture, and it will identify the exact line to which the denture must be trimmed.

CUTTING THE POSTERIOR PALATAL SEAL

The posterior palatal seal usually can be extended forward about 4 mm. from the distal border of the denture. It may be made a little wider than this in some areas, but in others, namely where it passes through the hamular notch, it will narrow down to only 2 mm. in width (Fig. 7). The depth of the posterior palatal seal

Fig. 7.

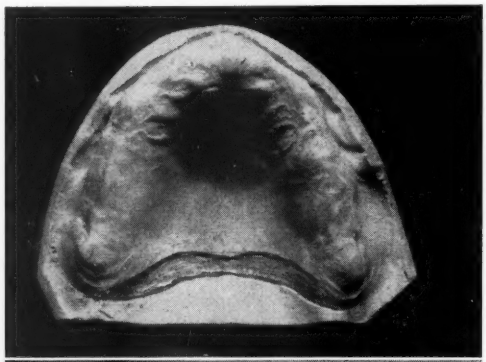


Fig. 8.

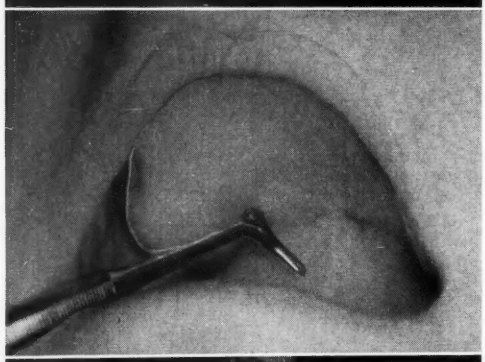


Fig. 9.

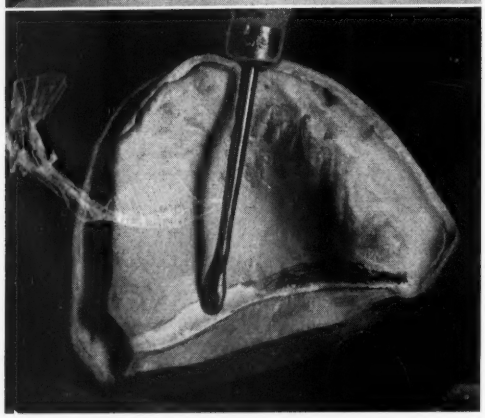


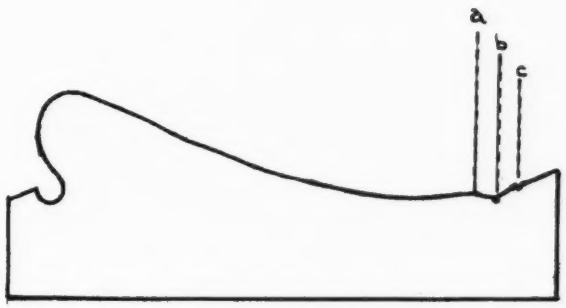
Fig. 7.—The outline of the posterior palatal seal is marked on the cast.

Fig. 8.—The displacability of the tissue in the posterior palatal seal area is determined with the ball portion of the *T* burnisher.

Fig. 9.—The cast is scraped to make the posterior palatal seal. It is scraped to approximately one-half the depth that the tissue in the mouth is displaceable.

will vary, also, in direct relation to the displaceability of the soft tissue which underlies it. The amount of displaceability of the tissue is ascertained by pressing the ball portion of the *T* burnisher into the tissue of the mouth lightly and ascertaining the depth to which the ball buries itself in the tissue (Fig. 8). At the midline of the palate, there may be very little tendency of the tissue to yield, then again there may be considerable tissue yielding. As a rule, the tissues lying laterally to the median line will show more resiliency and the tissues through the hamular notch will generally be readily displaceable.

Fig. 10.



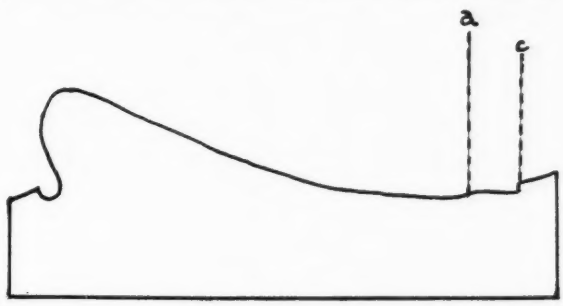




Fig. 11.

Fig. 10.—The correct cross-section shape of the posterior palatal seal. *A*, The anterior border of the posterior palatal seal. *B*, The center and deepest part of the posterior palatal seal area is scored with a small groove for additional sealing. *C*, The distal border groove of the denture.

Fig. 11.—An incorrect shape of the posterior palatal seal. *A*, The anterior border of the seal. *C*, The deepest sharp wedge-shaped distal border of the posterior palatal seal often causes irritation of the tissue.

The posterior palatal seal is developed by scraping the cast to a depth of about one-half the amount to which the tissue in that area is displaceable (Fig. 9). The scraping of the cast is done by means of a scraper and in such a fashion that the depth of the posterior palatal seal is maximum at the center and tapers to zero toward its anterior and posterior borders (Fig. 10). Irritation of the tissue due to the sharp wedge-shaped posterior palatal seal has been observed when the cast was scored deepest at the distal border of the denture and tapered to zero anteriorly (Fig. 11).

Fig. 12.

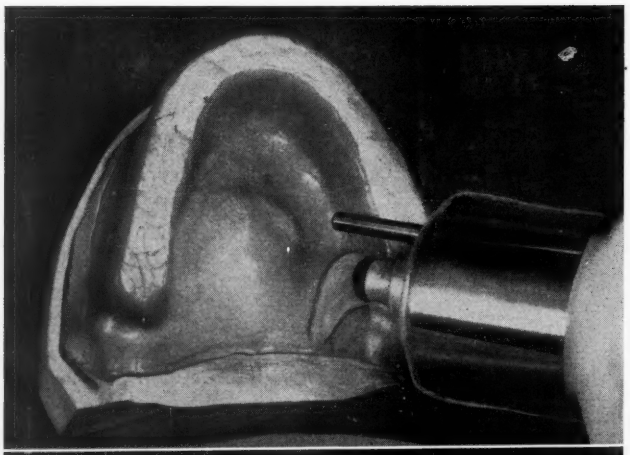


Fig. 13.

Fig. 12.—The adaptation of the baseplate to the scraped area is accomplished with a needle point flame.

Fig. 13.—The adaptation of the baseplate is completed, and the occlusion rim is tested for retention in the patient's mouth.

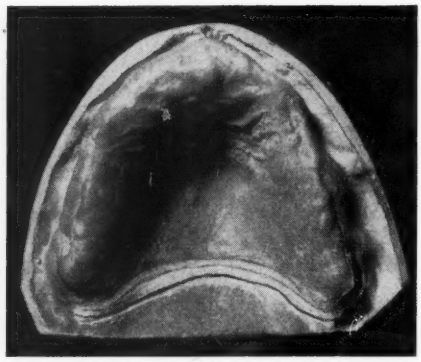


Fig. 14.—The completed posterior palatal seal contains a scored line in the center which represents the safety factor. This is to allow for the shrinkage of the acrylic resin during processing.

A posterior palatal seal is necessary because the distal border of the denture is the least advantageous of all the borders for providing a seal for retention. The labial and buccal denture borders are generally well sealed by the draping of the soft tissues over them, but there is no lip or cheek to drape over the posterior border of a denture. Also, the deficiencies in our present denture bases, which admittedly

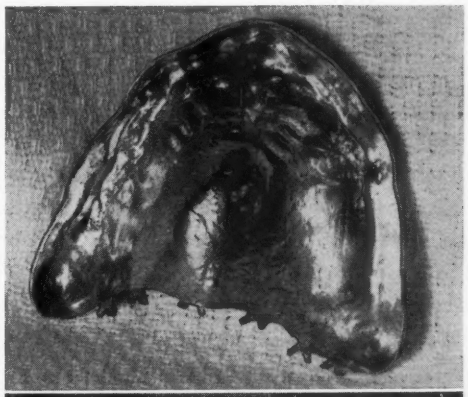


Fig. 15.

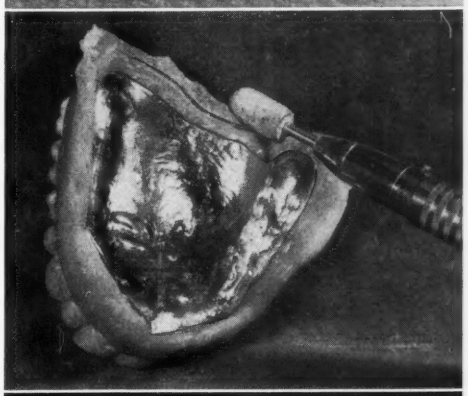


Fig. 16.

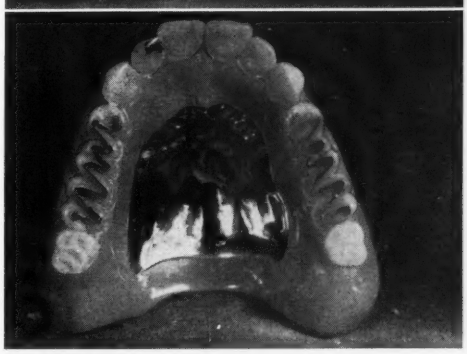


Fig. 17.

Fig. 15.—A metal palatal casting with projecting fingers for the acrylic attachment of the resin posterior palatal seal.

Fig. 16.—The acrylic resin can be trimmed away from the posterior palatal seal to make adjustments in this region.

Fig. 17.—The completed denture with a metal palate is constructed with all of its borders made of acrylic resin.

do not process to a true fit, necessitate sealing the posterior border more effectively.

After the cast has been scraped sufficiently, the occlusion rim is returned to the cast, and that portion of the baseplate overlying the scraped area is readapted meticulously to the altered cast (Figs. 12 and 13). The occlusion rim is again carried to the mouth, and the retention is tested.

To test for retention, a vertical pressure is applied to the occlusion rim, unilaterally, in imitation of the force that will be applied to the finished denture when the patient is chewing. If the readapted baseplate resists dislodgment when this test is made, it is considered satisfactory, and the finished denture should exhibit at least similar retention.

However, due to the relative instability of the denture base materials generally used, we take the added precaution of scoring the cast at the deepest point of the posterior palatal seal (Fig. 14). This score mark is similar to the one used to denote the distal border of the denture. This is merely a "safety" factor, but it might serve to counteract a warpage of the denture base. If this bead causes any irritation when the denture is worn, it can be buffed off very easily, so no harm is done by adding it, and it may make the difference between excellent and merely passable retention.

## POSTERIOR PALATAL SEAL FOR METAL BASE DENTURES

Metal denture bases possess certain advantages over acrylic resin bases. However, considerable difficulty has been encountered in using metal because of the fact that if the posterior palatal seal was incorrect, there was very little chance of correcting it. About ten years ago, Hardy reasoned that if all of the other denture borders are made in acrylic resin there should be no logical reason why the distal border as well could not be made in acrylic resin. The procedure described for developing a posterior palatal seal was adapted for use with metal bases (Figs. 15, 16, and 17). Any necessary changes in the posterior palatal seal have been made for these dentures as readily as if they were made entirely of acrylic resin.

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# TOOTH POSITION IN RELATION TO THE DENTURE BASE FOUNDATION

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MUCH HAS BEEN WRITTEN about impression techniques, materials, tooth forms, articulators, jaw relation record making, and occlusal equilibration. Each of these subjects has a great deal to do with the success of complete and partial dentures. Articles about tooth position in relation to the denture base seem to be conspicuous by their absence. Due to the demands of time, the great bulk of the laboratory phases of denture fabrication is performed by commercial dental laboratories. Some compromises in tooth position are made due to the lack of patient education, laboratory problems, and perhaps because of a lack of a thorough understanding of the tissue sequellae.

This article is devoted to the relation of tooth position to the denture base.

## ANTERIOR MAXILLARY TOOTH POSITION

When the anterior maxillary teeth are positioned, the incisal line is usually determined by the lip line. The incisal edges placed 2 to 3 mm. below the relaxed lip line usually give the most esthetic result. The arch curvature should be constructed in relation to the type of arch curvature of the alveolar ridge, the type of facial contour of the patient, and the maxillary lip position.

*Square Arch Position.*—The most common error is setting the teeth into a square arch form on a tapering or ovoid residual alveolar ridge (Fig. 1). This causes the canines to be more labial to the crest of the maxillary ridge than the central incisors. As a result, the maxillary bicuspids will also be more buccal to the ridge than they should be.

Working side occlusal pressure will produce a displacing tendency (Fig. 2) that may cause an unnecessary search for a superior impression material or technique. Stability depends upon a proper impression as well as upon the correct tooth position in relation to the denture base. Both are essential.

*Normal Anterior Alveolar Resorption.*—The labial axial inclination of the natural anterior teeth places the incisal edges labial to the fulcrum about which the tooth would tend to rotate when under incisal force (Fig. 3, *Left*). In other words, the occlusal contact area is anterior to the alveolar support.[1] Therefore, if the prosthetic tooth was placed in exactly the same position as the natural crown, it would be labial to the alveolar support (Fig. 3, *Center*). More labial bone may

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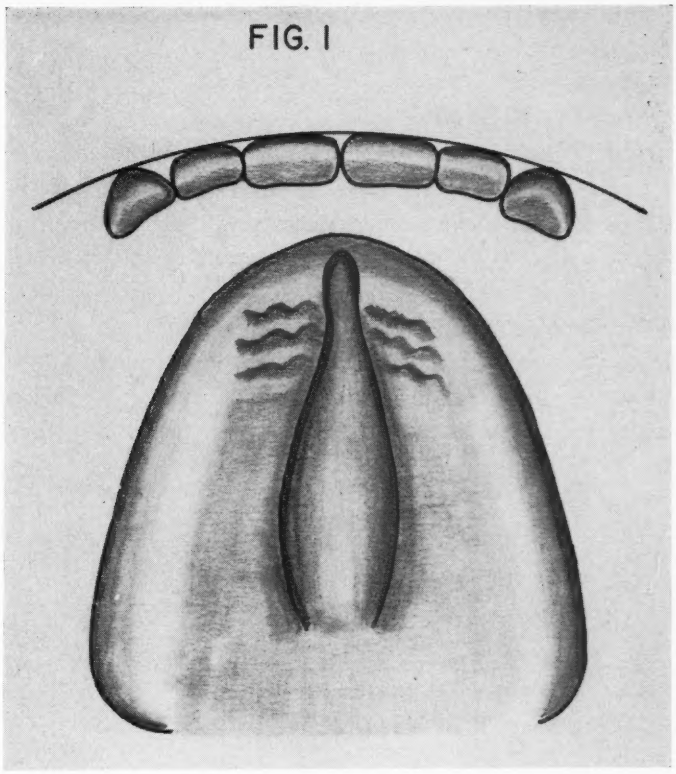


Fig. 1.—A square arch form arranged on a tapering or ovoid residual ridge causes the canine teeth to be more labial to the crest of the maxillary ridge than the central incisors.

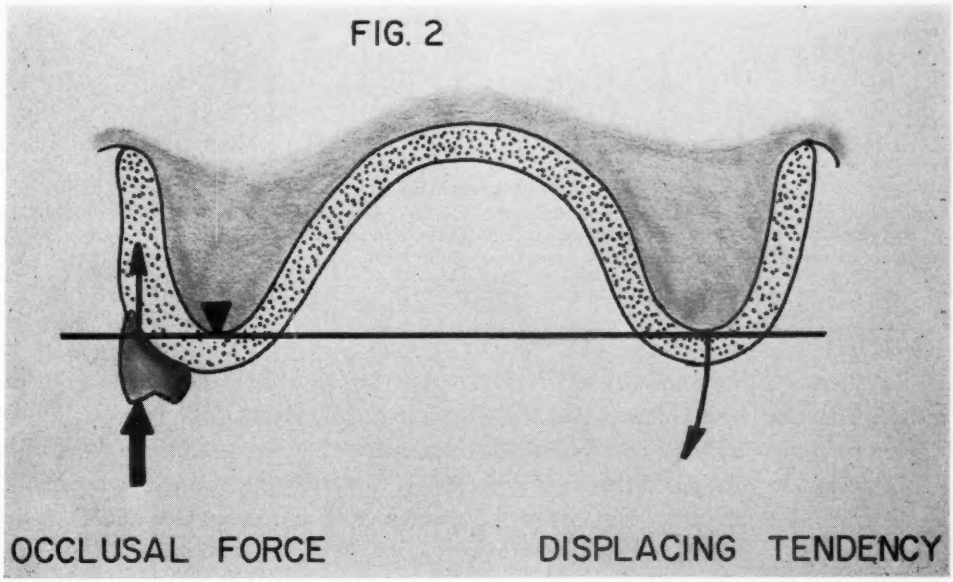


Fig. 2.—The maxillary bicuspids will also be more buccal to the ridge than they should be as a result of the labial position of the canines (Fig. 1). Occlusal pressure on the working side will cause a displacing tendency. The crest of the ridge acts as the fulcrum.

be lost due to alveolectomy because of esthetics and tissue undercuts. Advanced residual ridge atrophy adds to the problem.

The net result is a mechanically unfavorable tooth position in relation to the denture base foundation (Fig. 3, *Right*). However, this position is required by esthetics and function. If this acknowledged unfavorable relationship is combined with the error of a square arch setup on a tapering residual alveolar ridge, unnecessary torques and instability are created.

*Mandibular Anterior Tooth Position.*—The mandibular anterior tooth positions must conform to the maxillary arch. Any errors in maxillary tooth position will be transferred to the mandibular arch. A clinical illustration of this problem is the fact that patients are advised to bite off food in a special way to avoid denture displacement.

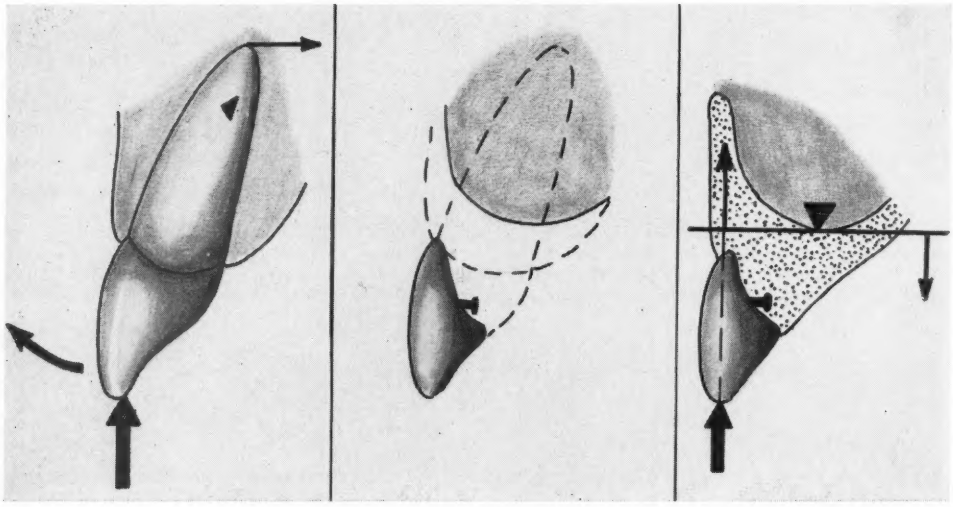

Fig. 3.—*Left,* The labial axial inclination of the natural anterior tooth places the incisal edge labial to the center of rotation of the tooth. *Center,* If the prosthetic tooth is placed exactly in the same position as the natural crown, it will be labial to the ridge support. *Right,* Incisal pressure causes a displacing torque.

## POSTERIOR ALVEOLAR RIDGE RELATIONSHIP

*Posterior Axial Inclination.*—Natural posterior maxillary teeth have a buccal axial inclination while mandibular teeth have a lingual axial inclination (Fig. 4). The normal alveolar bone resorption that takes place after extraction can result in a slight cross-bite relationship of the ridge crests (Fig. 5, *Left*). This is not difficult to visualize since the bony support of the mandibular teeth is slightly buccal to the maxillary bony support before extractions.

Due to the buccal plate reduction in surgical procedures, this cross-bite tendency is augmented. Finally, any advanced resorption of the alveolar process usually results in complete cross-bite ridge relationship (Fig. 5, *Right*).

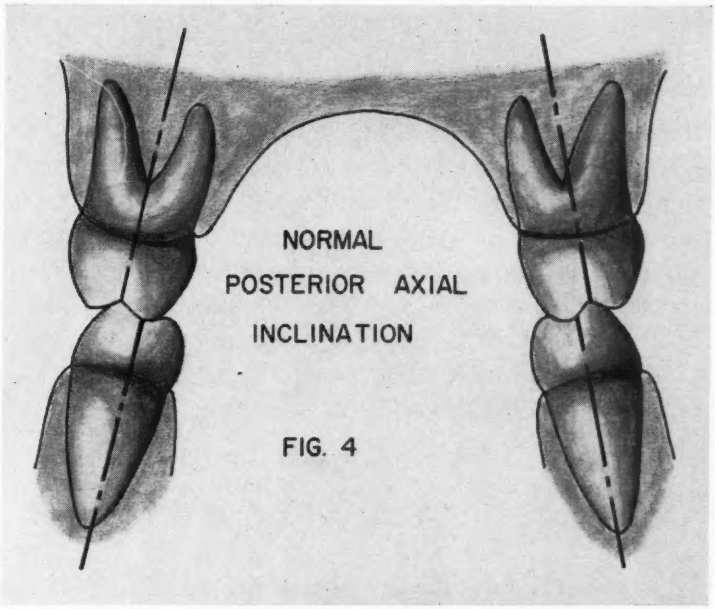


Fig. 4.—Natural posterior maxillary teeth have a buccal axial inclination, and the mandibular teeth have a normal lingual axial inclination.

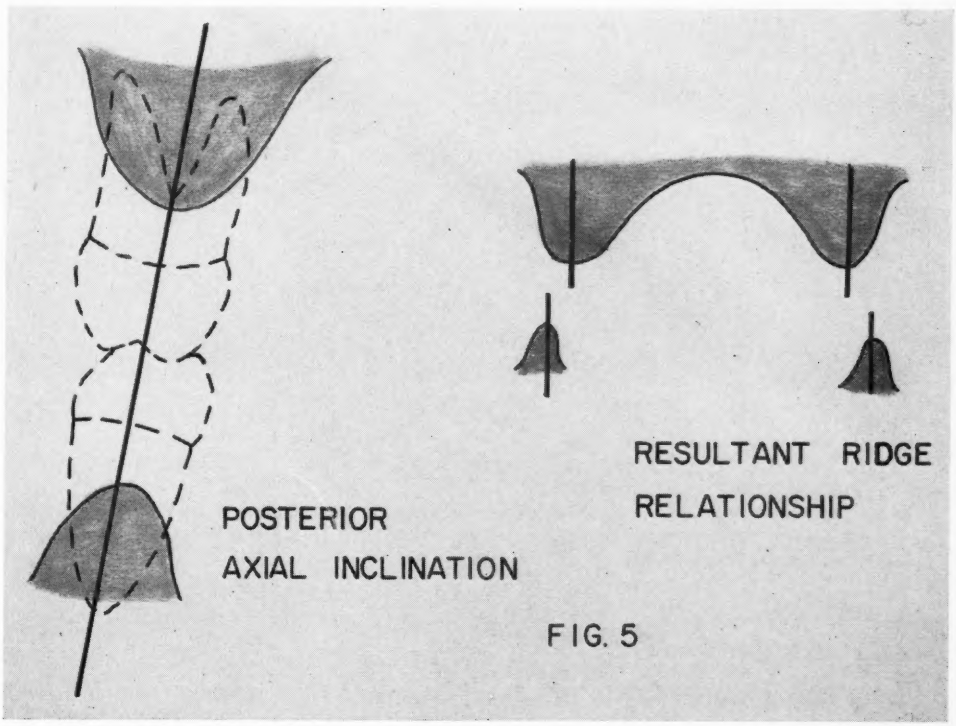


Fig. 5.—The normal residual alveolar ridge resorption that takes place after extraction can result in a slight cross-bite relationship of the ridge crests due to the axial inclination of the posterior teeth.

POSTERIOR MANDIBULAR TOOTH POSITION

Many laboratory technicians avoid ridge lap grinding, made necessary by the limits of space and the thickness of the baseplates, by placing the lower posterior teeth buccal to the ridge. The tooth is positioned so as to have the lingual cusp and fossa over the crest of the ridge (Fig. 6) and, if poor lingual cusp contact exists on the working side excursions, displacing torques develop. The buccal cusp of the lower tooth is buccal to the center of the alveolar crest which acts as the fulcrum (Fig. 7). Thus, a displacing force is created by poor tooth position. The lingual cusp creates no torque. If the guiding inclines of the cusps are not reduced and equilibrated on a suitable articulator, more lateral force will be added.[2-5]

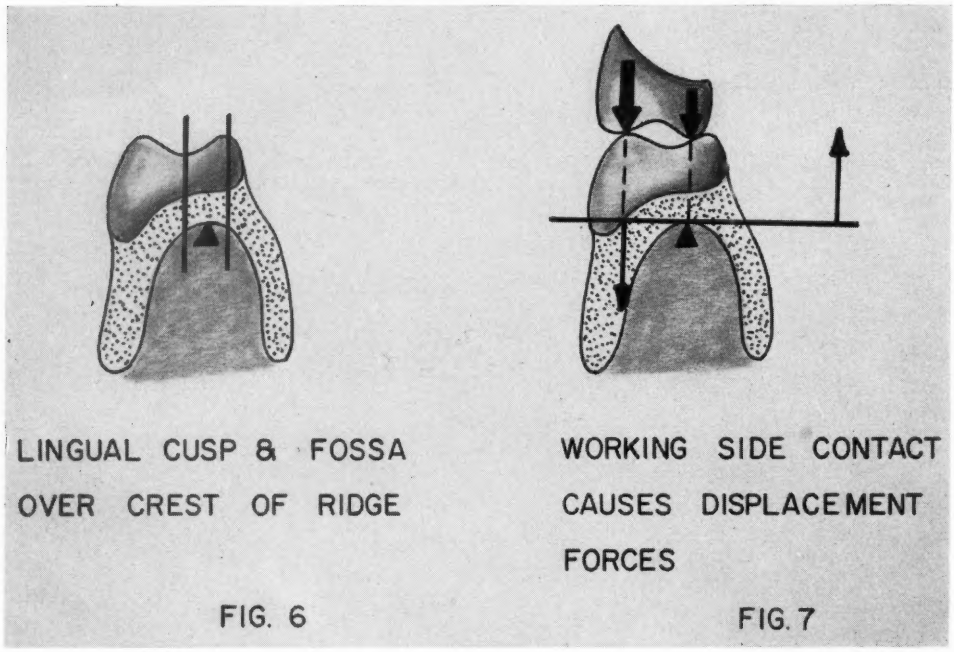


Fig. 6. Fig. 7

Fig. 6.—Mandibular posterior teeth are frequently positioned so as to have the lingual cusp and the fossa over the crest of the ridge.

Fig. 7.—The buccal cusp of the lower tooth is buccal to the center of the ridge crest which acts as a fulcrum. Thus, a displacing force is created by poor tooth position. The lingual cusp creates no compensating torque.

CORRECT TOOTH POSITION

The buccal cusp and fossa of the posterior mandibular tooth should be directly over the crest of the ridge (Fig. 8). The difference between this position and that illustrated in Fig. 6 is about 2 mm. in the lingual direction. This position results in more stability and less lateral force because occlusal pressure on the tooth falls

close to the fulcrum and creates little or no torque. To set the tooth in this position, the buccal aspect of the ridge lap of the porcelain tooth and the denture base may have to be ground in that area. The amount of grinding would depend on the space available between the maxillary and mandibular ridges.

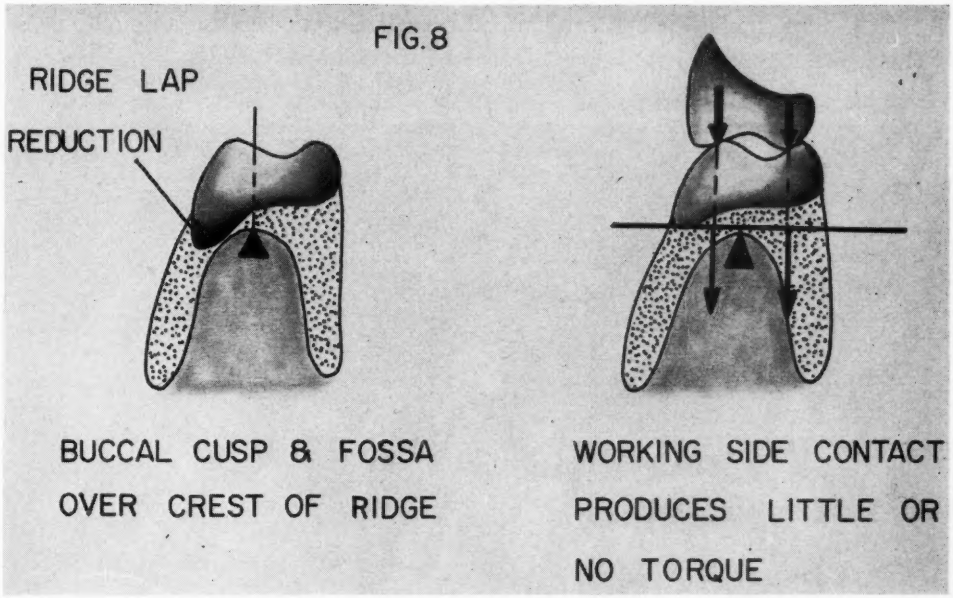


Fig. 8.—The buccal cusps and fossae of the posterior mandibular teeth should be directly over the crest of the ridge. *Left,* Grinding of the denture base and ridge lap of the tooth may be necessary. *Right,* The working side contact produces little or no torque.

## POSTERIOR MAXILLARY TOOTH POSITION

The posterior maxillary teeth are set too far buccally for various reasons:

1. An anterior square arch form set on an ovoid ridge (Fig. 1). This would cause the canines and bicuspids to be placed buccal to the ridge (Fig. 2).

2. A slight cross-bite relation of the ridges. This would be due to the axial inclination of the natural teeth before extraction (Fig. 4).

3. Advanced alveolar atrophy. This would tend to increase the cross-bite relation of the ridges (Fig. 5).

4. Placement of the mandibular teeth slightly buccal to the crest of the ridge (Fig. 6).

5. The tendency to avoid cross-bite setups results in placing the maxillary posterior teeth in a buccal position (Fig. 9).

Working side occlusal pressure causes a displacing tendency because the line of force is buccal to the fulcrum (Fig. 9). More lateral pressure is exerted on the

residual alveolar ridges, and this results in more rapid resorption. Perhaps, because we can usually give the patient more stability and retention on the maxillary denture, we tend to abuse it. Another reason for the general avoidance of a cross-bite is the lack of understanding of its equilibration.[6] A cross-bite relation is less efficient than normal buccolingual tooth relations. However, a cross-bite on a very stable base is better than a normal buccolingual relation of teeth on an unstable, damaging base.

It is important to polish equilibrated porcelain teeth because a rough surface can increase the lateral forces distributed to the denture base.[7]

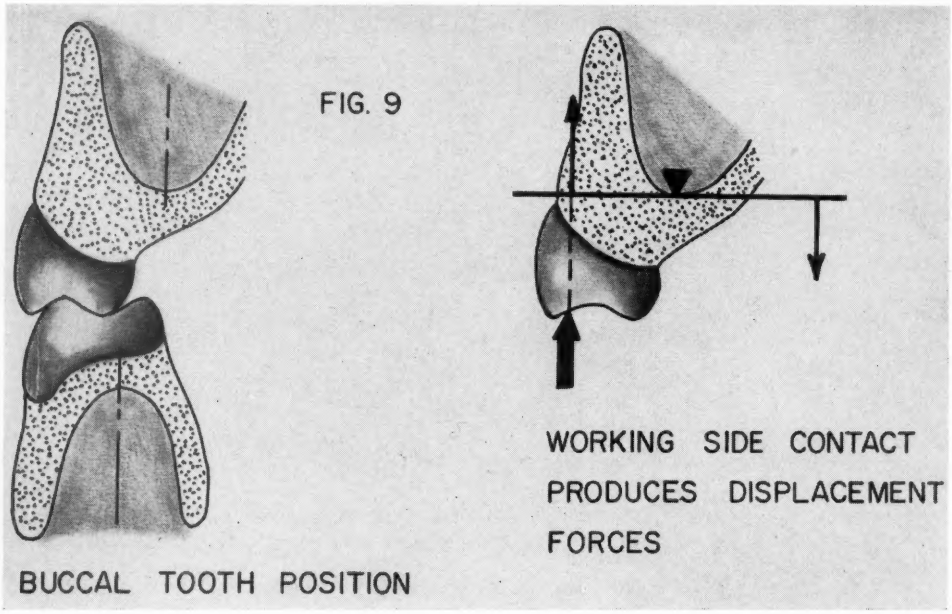


Fig. 9.—*Left,* The buccal tooth positions on mandibular and maxillary denture bases. *Right,* Working side occlusal pressure causes a displacing tendency because the line of force is buccal to the fulcrum.

SUMMARY

The maxillary anterior teeth may be placed too far labially in relation to the alveolar ridge because of an incorrect arch contour. This causes the maxillary bicuspids to be placed buccal to the residual alveolar ridge. The arch form of the mandibular anterior teeth must conform to the maxillary arch form, thus the error is duplicated. The axial inclination of the posterior natural teeth places the alveolar ridges in a slight cross-bite relation. Advanced alveolar ridge resorption or surgical procedures tend to increase this cross-bite ridge relationship. Placing the mandibular posterior teeth slightly toward the buccal side of the ridge causes displacement forces and faster alveolar ridge resorption.

Due to the general reluctance to utilize the cross-bite setup, the maxillary teeth are often placed far buccal to the ridge. This causes displacing forces and residual

alveolar ridge recession. If we keep these relationships in mind and use the crossbite setup where indicated, more comfortable longer lasting prostheses are possible.

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# TECHNIQUE FOR DUPLICATING AN ACRYLIC RESIN DENTURE

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THE PRODUCTION OF A DUPLICATE of a complete denture has been a problem which has always caused us considerable concern, especially whenever we found ourselves with the necessity of obtaining something similar.

Several patients, wearing dentures to which they are fully accustomed, asked us to provide them with second dentures identical to the ones they were wearing. This led us to try several techniques and experiments until we had succeeded in finding a means for constructing a duplicate denture. From the various techniques applied, we ended with two methods, of which we adopted only one, because the other, in addition to being complicated, did not produce a faithful replica of the denture to be reproduced.

## THE DUPLICATION PROCEDURES

The denture to be reproduced is carefully cleaned, and, if necessary, a new impression is obtained in the denture with a zinc oxide and eugenol impression paste. The denture is used as a tray in the following manner: Two holes are bored 10 mm. apart on the lingual and palatal sections of the denture and in the premolar area on either side by means of a No. 5 bur. The holes have two purposes: first, to serve as an exit aperture for the excess paste so as to avoid pressure when making the impression, and second, to serve as a place of attachment for a heavy thread. The thread serves as a handle for the withdrawal of the impression from the mouth (Fig. 1).

A hard stone cast is poured in the impression thus obtained. After the stone is set, the cast is carefully removed. At this stage, attention should be given to the following: If there are undercuts in the vestibular section or elsewhere in the denture which prevent its removal from the cast (Fig. 2), these are incised by means of a separating disk, and, prior to their removal, a plaster impression is made of only that portion where the separation occurred. Then these are detached to allow the removal of the cast.

After shaping the cast, deep notches are cut on either side, and a hole 3 mm. in diameter is bored in its center (Fig. 3). The denture is carefully replaced in the cast along with the precut sections, if any, and all of the parts are stuck together with wax. The denture is reshaped, and the excess impression paste and the two thread ligatures are removed.

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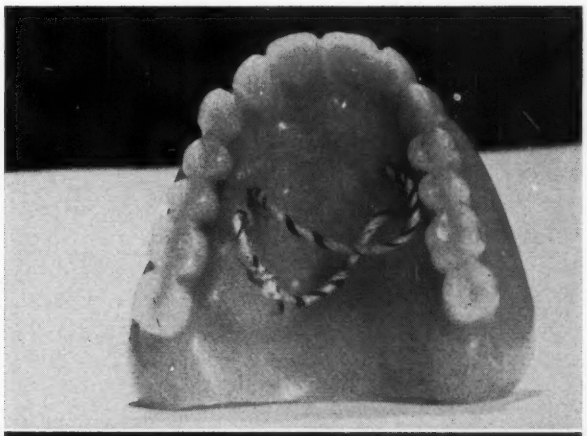

Fig. 1.

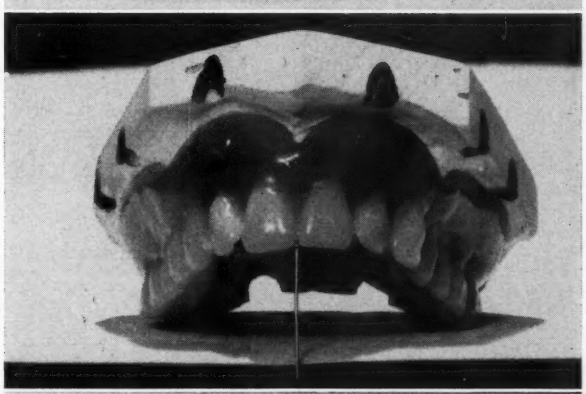

Fig. 2.

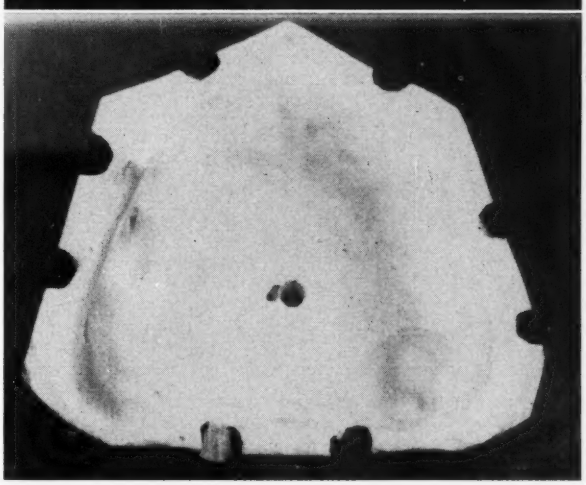

Fig. 3.

Fig. 1.—A denture prepared for a relining impression with a heavy thread looped through holes in the palate.

Fig. 2.—The labial flange is cut so the denture can be removed from the cast.

Fig. 3.—The notched cast with an escape hole provided in the palate. The hole permits air and excess wax to escape from the hydrocolloid mold.

The denture on the cast is transferred and lightly secured with wax to the base of the duplicating flask (Fig. 4), and hydrocolloid is poured around it in accordance with the usual duplicating method.

After the hydrocolloid cools and sets, the cast and the denture are taken out of the hydrocolloid, and the denture is carefully removed from the cast (Fig. 5). The cast and the hydrocolloid mold are placed in water at 40° C. to 45° C. and allowed to remain there.

Fig. 4.

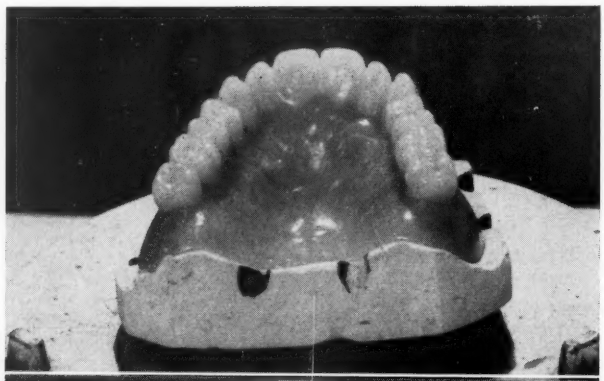

Fig. 5.

Fig. 4.—The keyed cast and the denture to be duplicated are attached to the base of the duplicating flask.

Fig. 5.—The cast and denture are removed from the hydrocolloid mold. Note the "keys" in the mold.

A quantity of ordinary laboratory wax of red or rosy color is melted in a hot water bath and maintained at a temperature of 65° C. to 70° C. The hydrocolloid mold is removed from the warm water and air dried. Then the wax is poured into the hydrocolloid mold, and the cast is placed into the duplicating flask immediately. Care is taken to place it properly into the grooves in the mold. The cover of the duplicating flask is adjusted, and a light pressure is applied (Fig. 6). The flask is opened after a lapse of six hours, which allows the wax to

harden slowly so as to avoid sudden contraction, and the first duplicate denture is obtained (Fig. 7). The wax replica obtained is placed in the usual flask, and the denture is completed in the usual manner. The duplicate thus obtained differs in no way from the original denture (Fig. 8).

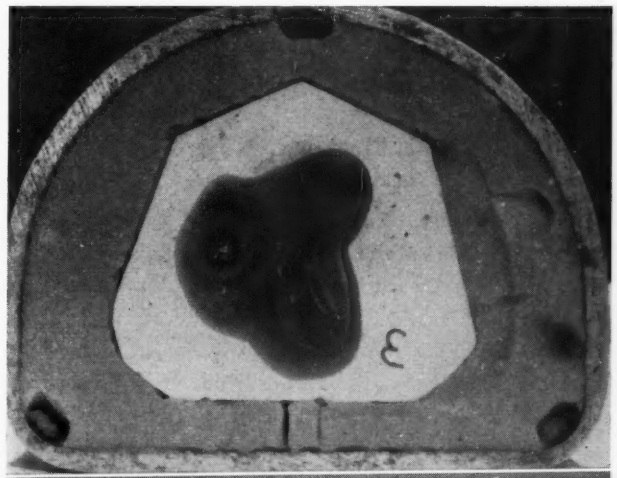

Fig. 6.

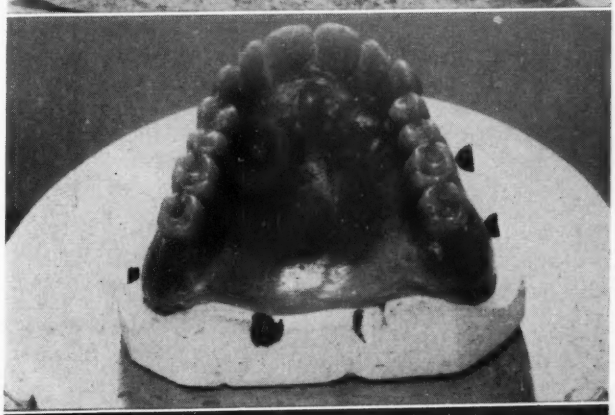

Fig. 7.

Fig. 8.

**Fig. 6.—The cast is placed back in the mold after the denture has been removed, and the mold is filled with molten wax. The excess wax escapes through the hole in the cast.**

**Fig. 7.—The wax pattern of the duplicate denture.**

**Fig. 8.—Left, the duplicate, and right, the original denture.**

DISCUSSION

Care should be taken to avoid altering the cast when detaching it from the denture. For this reason, we advise cutting or sectioning the denture in those parts where undercuts exist.

The purpose of the incisions is to permit the denture to be readapted perfectly when it is set back on the cast.

The hole is bored in the center of the cast to provide an outlet for entrapped air and excess wax at the time the cast is set back on the hydrocolloid (Fig. 6).

The flask containing the hydrocolloid should be kept in water at 40° C. to 45° C., and the cast and wax should be kept in water at 65° C. to 70° C. so as not to have a great difference in temperature at the time the wax is poured. This minimizes the contraction of the wax.

It is advisable to use an excess of wax to fill the mold, and any excess will escape from the central hole bored in the cast when it is settled into position in the hydrocolloid mold.

Accelerated cooling will cause sudden contraction of the wax and it should be avoided. For this reason, it is considered advisable to wait six hours before withdrawing the cast from the hydrocolloid mold.

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# A PRELIMINARY REPORT ON RESILIENT DENTURE PLASTICS

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IT HAS ONLY BEEN THE LACK of a suitable material that has prevented the extensive use of resilient denture base materials in complete denture prosthetics. The combined use of soft and hard plastics may give superior results in the following circumstances: (1) in the complete lower denture where the patient shows a marked senile atrophy, (2) in developing maximal retention where the residual ridges are bilaterally undercut, (3) in mouths where a hard median palatal raphé is associated with a poor retentive potentiality, and (4) in obturators for acquired and congenital clefts of the palate.

## COMPLETE LOWER DENTURE WHERE THE PATIENT SHOWS A SENILE ATROPHY

Whereas in youth anabolic processes predominate, in old age catabolism is in the ascendancy and atrophies result. The oral tissues share in this process,[1] and the effect is noted on the mucous membrane, the musculature, and the bone (Fig. 1). The mucosa, as well as showing a reduction in the number of cell layers comprising the thickness of the tissue, also shows a reduction in surface area. The lamina propria likewise is reduced in thickness and, accordingly, the mandibular residual ridge comes to be covered by a thin layer of soft tissue. In general, there is an inward migration of the origins of the buccinator and mentalis muscles, and this effectively reduces the area of residual ridge bone which can accept the load. The bone may be either of a dense cortical type or a noncortical type, the latter commonly being seen in roentgenographs of the anterior ridge (Fig. 2). When load is applied through a hard denture base in such cases, pain is very likely to result. The pain nerve endings are compressed between the thin mucosa and the sharp, vertical, spicules. Even in severe cases, comfort may be obtained by making a complete lower denture with a soft lining. The basis of this therapy is the replacement of the missing resilient tissue layer covering the residual ridge by a similar layer on the base of the denture. The mechanism involved is that part of the energy transferred to the lower denture is used in deforming the denture base elastically. Further, an equalization of pressure is effected over the bone of the ridge so that the prominent spicules are not called upon to resist the greater amount of the applied force. In practice, patients who have had dentures with perfectly even distribution of the occlusal forces on the teeth have found comfort only when a resilient denture base has been substituted for a hard one.

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MAXIMAL RETENTION WHERE THE RIDGES ARE BILATERALLY UNDERCUT

When bilateral undercuts exist, the treatment of choice is the surgical reduction of the residual ridges. However, many patients will not sanction such an operation, and in a few there may be definite contraindications to surgery. It is usual, in such cases, to thicken the acrylic resin in the undercut area and to remove some of this from the impression surface of the denture to facilitate an easy insertion of the denture. Unfortunately, the inclusion of an air entrapment between the cut surface of the base and the ridge mucosa causes a reduction in the retentive capacity of the denture.[2] This handicap need not arise when a resilient plastic is available. If a soft material replaces the hard resin which lies beneath the undercut, it can

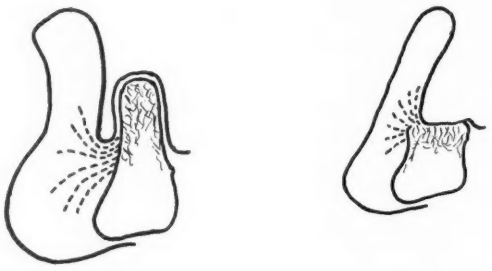

Fig. 1.—A diagrammatic representation of atrophy in the lower anterior region. *Left,* the ridge is well preserved. *Right,* the ridge has suffered severe resorption and there has been a change in the origin of the mentalis muscle.

Fig. 2.—Roentgenograph of lower anterior region showing a lack of cortical covering.

readily be displaced upon insertion of the denture (Fig. 3). Upon the application of a displacing force, some of the energy must be used to spring the elastic flange over the maximal bulbosity of the ridge, and this helps to improve the retention. Even more important is the elimination of the air inclusion at the reflection of the vestibular sulcus.

MAXIMAL RETENTION IN A MOUTH WITH A HARD MEDIAN PALATAL RAPHÉ

It is often difficult to obtain good retention when the palate has a hard median palatal raphé or torus palatinus. Generally, the hard palate is large and square in the coronal section; if the alveolar ridges are well formed and if extractions have been recent, depressions remain showing previous root positions. The mucosa is

often more pale than normal, and palpation gives a hard feeling due to the absence of a lamina propria of substantial thickness; the median palatal raphé is particularly hard. Xerostomia is often an associated complication. In such cases, the difficulty lies in the lack of potentiality of the mucosa to adapt to the detail of the impression surface of the denture, which can only approach a perfect reproduction of the palatal form. The retentive potentiality in these cases is further reduced by the inclusion of a relief chamber over the exceptionally hard median raphé. This

Fig. 3.

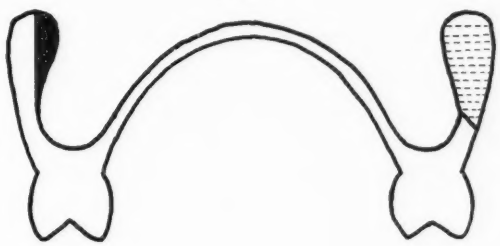

Fig. 4.

**Fig. 3.—On the left the shaded area of the flange indicates the amount of base material to be removed to allow insertion of the denture past the undercut. On the right, the flange is constructed entirely in a resilient material. There is an oblique line of junction between the hard and soft materials to give a greater area of contact.**

**Fig. 4.—An inlay of resilient material over the hard median palatal raphé.**

is due to an air entrapment in the salivary film between the impression surface of the denture and the palatal mucosa. This problem may be partly overcome by placing a soft base layer over the area outlined as the limits of the relief chamber (Fig. 4). This has the effect of distributing the load more generally over the maxillary ridge and palate and at the same time eliminating the air inclusion. The approach is, however, only an aid to better retention; it cannot be expected to give the degree of positive retention seen in normal mouths.

## OBTURATORS

With improved surgical methods in cleft palate surgery and advances in orthodontics,[3] the number of patients with gross deformities of hard and soft palates, who have been rendered edentulous in the upper jaw, will be reduced in the future. However, many patients in the older age group require complete dentures where clefts are very extensive. A soft material can be helpful in retaining such appli-

ances.[4] The soft resin is helpful in the fabrication of appliances required after radical jaw surgery, e.g., removal of a maxilla because of carcinoma. This soft material is well tolerated by the traumatized tissues, particularly where radiotherapy has been used.

## DESIRABLE PROPERTIES IN A SOFT DENTURE RESIN

*Ease of Processing.*—A simple processing technique would find wider acceptance than one which required either special equipment or a lengthy or critical procedure. Since acrylic resin is now so widely used as a denture base material, its simple processing technique in a water bath has come to be an accepted standard of ease of manipulation. Many of the materials which might be commended as possibilities for use as a soft denture base material cannot offer such simplicity.

*Dimensional Stability During Processing.*—It is important that the resilient resin does not suffer a marked dimensional change during processing. If contraction is marked, the adaptation of the denture to the mucosa covering the supporting bone is not adequate. The theoretical contraction is not completely effective if the processing contraction of the rigid denture base is less than that of the resilient resin. Although this results in better than theoretical adaptation, it can result only in a less dense layer of soft resin and a strained condition in the region of the bond between the two layers.

*Water Absorption.*—It is very important that the water absorption of a resilient resin used in the mouth should be very small. A high water absorption value has three important disadvantages. First, the fit of the appliance is ruined as a swelling of the material takes place; second, swelling will put further strain in the region of the bond between the two layers; and third, since bacteria and nutrient material in solution also find their way into the resin, it becomes unhygienic in use. However, the material should not be a water repellent or the thin film of saliva necessary in retention of the denture may be deficient.

*Bond Strength of the Resilient to the Rigid Resin.*—Although it is very desirable to have a high bond strength between the resilient and the rigid denture resins, the demand of the case must always be taken into account. When a buccal flange of soft material is used peripheral to the line of maximum contour on a denture extending into an undercut, the bond strength must be high since the unsupported resin is flexed frequently during insertion and removal, use, and cleaning. On the other hand, when a resilient resin is used as a lining material in a complete lower denture it is generally well supported by rigid denture base material, and a lower range of bond strength proves adequate. Where extensive flanging is indicated and where a low bond strength is noted, the situation can be overcome by making the border of the denture in hard resin and confining the margin of the soft resin to within 1.0 to 2 mm. of the border of the impression surface (Fig. 5). In this way, the soft material is completely encased in a box of hard resin and acts over the central ridge area where the bone is of a noncortical nature. The hard border overlying the buccal plate rests on cortical bone. The disadvantage of this approach is the concentration of the occlusal load on the tissues beneath the denture border.

*Abrasion Resistance.*—It is very desirable that a soft denture resin should have a high abrasion resistance. If the abrasion resistance is low, loss of surface in cleaning leads to a loss of accurate adaptation of the impression surface. The surface remaining after an abrasive action is not always smooth but often has a rippled appearance. This roughness forms an effective nidus for calculus deposition, and it is not uncommon to find such deposits, especially on the impression surface of the denture at the midline. It should be pointed out that an abrasion resistance of the order shown by a rigid base material can hardly be expected in the soft plastics. Accordingly, it is important to prefer chemical cleaning, combined with light brushing under running water, to rigorous treatment with a hard brush and severe abrasive powders.

Fig. 5.—*Left,* the resilient material forms the border of the denture. *Right,* the material is encased by the rest of the denture base material. *B,* buccal; *L,* lingual.

*Permanency of Resiliency.*—It is always desirable to have a soft material whose hardness remains unaltered after a protracted period of wear in the mouth. Where the soft resin is constantly being deformed to spring into an undercut, and thereby gain retention, it is imperative that the soft character be maintained. On the other hand, where a soft lining is used in a lower denture placed over an atrophic mucosa which covers noncortical bone, the use of a lining which hardens gradually over a period of time often gives a practical solution to the problem of pain. The necessary stipulation is that, in hardening, the soft resin should not change in dimension. It is common to find the development of fissures in some resins as the material hardens; these frequently occur over the crest of the ridge and result in the thin mucosa becoming entrapped and causing pain.

## CLINICAL INVESTIGATION

Case histories of 130 patients fitted with complete dentures, with soft resins used in their fabrication, have been kept in the Department of Dental Prosthetics of the University of Liverpool during the last four years. Records were made under the headings of patient history, oral examination, roentgenographic examination, treatment, and choice and technique of processing of the soft base. In the lower jaw, periapical and occlusal roentgenographs were taken, but in the upper, only periapical films were used. Recall of these patients is being carried out at least every six months; in addition, records are made if the patient presents for the treatment of any complication. On recall, as well as recording the patient's history,

examination of the oral condition and the denture base is carried out. Oral examination is visual, palpatory, and roentgenographic, while the condition of the resilient plastic is examined for color changes, hardening, evidence of abrasion, and bond.

Most of the patients under review have given histories of being unable to wear complete lower dentures on account of pain. Of 109 patients with this history, 91 have reported continued absence of symptoms or greatly improved comfort when a denture with a soft base has been substituted for one made entirely of a hard resin. It must be stressed, however, that the mere replacement of a hard base by a soft one is not always sufficient. Great attention must be paid to correct denture extension and to the development of an evenly balanced centric occlusion. It is more difficult to accomplish this latter requirement where a soft base is used, because the local compression of the elastic material allows for the development of an occlusion between all of the upper and lower teeth. Visual examination during slow closure can be very useful diagnostically, but closure into a very soft wax record, before mounting the dentures on an articulator using a face-bow, is the method of choice. Grinding is carried out following an examination of the dentures on the articulator.

Fig. 6.—*Left,* where there has been lack of ridge resorption, there is only a small amount of hard resin overlying the soft material (shaded black). *Right,* with greater ridge resorption, a large bulk of hard resin can be used, thus increasing the strength of the denture.

Recall studies have revealed the absence of ulceration under soft lining where this had been evident previously. However, the covered mucosa is quite injected, and there is no apparent marked increase in the keratinization of the covered mucosa; it maintains its atrophic character. The constancy of the roentgenographic picture is remarkable in view of the plastic nature of bone. It was felt that there might well have been reduction of vertical bony trabeculae where the bone was noncortical. However, this has not been noted to any extent. In the great majority of patients, the particular form and distribution of trabeculae and nutrient canals has been reproduced on serial roentgenograms taken at six-month intervals. Although a means of repositioning the film, head, and tube was not developed, comparable films have been obtained in the majority of patients.

With regard to the denture, it is found that where the ridge is markedly resorbed, this allows for a considerable bulk of hard resin in the appliance, which gives it adequate strength; fractures are not noted in this class of denture. On the other hand, if it is not possible to include a sufficiently thick layer of acrylic resin because of lack of ridge resorption, fracture of the denture is liable to occur (Fig. 6).

Six cases of this kind have been seen; these always present a considerable, if not unsurmountable, problem in repair.

Two materials* have been used for the fabrication of soft denture flanges extending into bilateral undercuts in 7 patients. An increase in retention has been noted. Difficulty was experienced in inserting the denture, however, when the undercut areas to be engaged were gross.

Only five dentures with soft material inlays over hard median raphés have been attempted. Here the results have been encouraging, if not spectacular.

Extension of this work into the use of soft materials for congenital cleft palate patients, and for use as obturators after major and minor oral surgery, is being carried out.

As well as providing a clinical assessment of the use of soft denture plastics under different conditions and the relative values of different soft lining materials, this investigation has been used to develop relevant laboratory tests which might give information as to how applicable the use of a soft material might be to prosthetic requirements.

## SOME OBSERVATIONS ON DIFFERENT SOFT DENTURE RESINS

It must be stressed that remarks on the use of different soft resins can be considered only of a preliminary nature. Different approaches in technique are being tried, and these have yet to stand clinical testing. However, some materials hold out hopes for the future, whereas others can be discarded as inadequate at this stage.

Different materials in the following classes have been used, and it is proposed to comment on each of these in some detail: (1) natural rubber, (2) polyvinyl chloride, (3) polyvinyl acetate, (4) methyl methacrylate copolymer, and (5) silicone products.

*Natural Rubber.*—When vulcanite was the denture material of choice, a soft natural rubber known as "velum" rubber was used in obturator work and as a soft lining for complete lower dentures. This product has a high water absorption and became foul and ill-fitting after a variable time in use. On this account its use was almost eliminated.

A large amount of the water absorption of this rubber was due to the presence of protein impurities. Accordingly, it was felt that a highly purified or "washed" natural rubber might yet prove useful.

It was felt that this material should be developed for use with acrylic resin rather than vulcanite; this posed problems in developing a bonding agent and also of producing a rubber with a low vulcanizing temperature. An experimental rubber with the following composition has been compounded:

| | |
|---|---|
| Rubber | 100 Parts |
| Zinc oxide | 2 Parts |
| Diethyl dithiocarbamate | 1 Part |
| Sym. Di-betanaphthyl-paraphenylenediamine | 1 Part |
| Stearic acid | 1 Part |
| Sulfur | 1 Part |
| Lime | 2 Parts |

*D. P. Veldent and Provinyl—p.Ultra.

A bond strength adequate only in 50 per cent of complete lower dentures where little flanging is present has been found to result when Desmodur R. is used to give a chemical bond between rubber and acrylic resin; this commercial bonding agent is essentially a p-p′-p″ tricarbimido-triphenylmethane in methane chloride. This has necessitated a double processing technique, and difficulty has arisen with regard to effecting a trial closure of the flask after packing the unvulcanized natural rubber. Reduction of the viscosity of the rubber sheet prior to packing was first carried out in the traditional method of heating it over a hot plate. Unfortunately, this resulted in partial vulcanization and hardening, and the technique had to be discontinued. Now the rubber is prepared for packing by rolling, when a more plastic product is obtained. Packing is done in a cold flask. With experience, the technician learns to gauge the amount of rubber required and becomes adept at packing it in an even layer. Curing is carried out in boiling water.

The disadvantages of the material as presently developed are: (1) The bond strength is variable and only adequate when supported. (2) The gray color of rubber and the deep red color caused by the bonding agent are not esthetically good. (3) Technical difficulties can only be overcome by experience and skill. (4) A double cure of the acrylic resin is necessary.

*Polyvinyl Chloride.*—As used as a plastic, polyvinyl chloride is in the gel condition. It is stabilized against breakdown and the production of free hydrochloric acid by the inclusion of chemical stabilizers; many different chemicals have been used for this purpose in industry, many of which are nontoxic, so that little problem arises with regard to stabilizing the gel for use in the mouth. In addition, a plasticiser or combination of several plasticisers are used. Their purpose is to give a paste which can be packed into a mold, to reduce the gelling temperature, and to control the softness of the product.

One mixture[5] may be considered typical of those used in the past in association with acrylic resin:

| | |
|---|---|
| Polyvinyl chloride (Corvic S.U.) | 6.5 Parts by volume |
| Calcium stearate | 1 Part by volume |
| Zinc oxide | 1 Part by volume |

This powder is mixed with an equal volume of dibutyl phthalate. As commonly used, the cast surface in the mold is covered by a spacer of two layers of gauge 7 soft metal, and trial closures are effected after packing with acrylic resin dough. When the correct amount of resin fills the mold, the spacer is removed and some P.V.C. paste is placed in the resultant mold space. Curing is generally carried out either in a thermostatically controlled hot air oven or in an electrically heated press. The resultant denture may suffer from many disadvantages.

First, the gelation temperature of the polyvinyl chloride is quite critical. Failure to reach the required temperature results in a weak mass of a cheeselike consistency, whereas overheating results in a decomposition with charring. An average gelling temperature may be 160° C., but this figure must be modified for each mix in light of its plasticiser content; the amount and nature of the plasticiser present affect this temperature. Further, it is not sufficient to assume that if the

outside of the flask is at 160° C. after a certain time the interior of the mold will be. The only way to regulate the mold temperature is by inserting a thermometer or a thermocouple into the investing plaster in close relation to the mold surface.

Second, if such a denture is examined, it is found that the pink denture base is paler than usual and has a more homogeneous appearance. If acrylic resin teeth have been used, these have an even, white, monochrome appearance which is quite unacceptable esthetically. The melting point of acrylic resin is below the gelling temperature of polyvinyl chloride, and this accounts for the changes in its appearance. Further, if the mold is not entirely enclosed by tin foil, water from the decomposing plaster will act on the acrylic resin with deleterious results.

Third, it is found that after a varying period of time in the mouth the soft lining hardens and fissures form in its surface. This may be evident after six to twelve months. The mechanism is migration of the dibutyl phthalate plasticiser into the saliva and adjacent acrylic resin. A noteworthy point is that in the lower denture hardening is always first noted on the surface covering the buccal alveolar plate in the molar region; this is a relatively stagnant area and here bacterial fermentation of carbohydrate food debris may take place with the liberation of organic acids, especially lactic acid. It is known that lactic acid, even in weak solution, facilitates a migration of the plasticiser from the vinyl resin. Dioctyl phthalate has been suggested as an alternative[6] but results are little better. Recently, a group of "nonmigratory" plasticisers of long-chain length have been marketed; some of these are toxic but others are not, and the latter group would seem to offer a solution to the problem of hardening. Several dentures with polyvinyl chloride linings, plasticised by chemicals of this group, have been in the mouth for 18 months; it is, however, too early to make any comment other than the time that the base remains soft is increased.

Two methods have been used to avoid processing the acrylic resin above 100° C. First a pregelled sheet of P.V.C. may be cut to the contour of the lower cast and adapted over the cast surface before packing the flask. The disadvantages of the material are its lack of ability to reproduce detail and the strained condition in the bond area. Second, the polyvinyl lining and the rigid acrylic base may be fabricated separately then united with a cementing medium. This last approach is the one which is being tried at present, but again it is too early to comment on the permanency of the bond strength.

A final approach is to use a polyvinyl chloride, acrylic resin mixture as a soft base. Processing of this is carried out at 100° C. in a water bath and a one-cure technique is used. The aim in this case is to accept a hardening of the material and at the same time to procure a hardened product which is free from cracking. A commercial product of this nature which has proved satisfactory has been developed by Dr. Jarby of Copenhagen and is sold under the trade name of Provinyl-p.Ultra. Fifty-one lower dentures lined with this material have been inserted in the mouth. Clinically, the bond strength has seemed superior to that of the other materials used, and resiliency has been maintained in some cases for a period of 18 months. In others, however, there has been the familiar hardening, cracking, and breakdown of the bond with the acrylic resin base material. Vernosoft, an American product, has been tried recently in three dentures. At the time of last recall, eight months after insertion, the resiliency was being maintained.

The great disadvantages of polyvinyl chloride result from its high and critical gelling temperature. On the other hand, its dimensional stability in processing, its low water absorption, and good bonding potentiality to acrylic resin suggest that it might well become the material of choice.

*Polyvinyl Acetate.*—Since it has not been found possible to reduce the gelling temperature of polyvinyl chloride to 100° C. through the use of plasticisers, attempts have been made to use polyvinyl acetate. The gelling temperature of this chemical can readily be reduced below 100° C. Unfortunately, this product has a high water absorption which definitely contraindicates its use in the mouth. A proprietary product known as Jospi is basically a plasticised polyvinyl acetate. This shows considerable water absorption and migration of the plasticiser resulting in hardening after several months. The lining becomes stained and cracks in the mouth, contraindicating its use.

*Plastupalat.*—This German product, which is a copolymer of 35 parts of methyl methacrylate with 65 parts of the butyl ester of acrylic acid, is used as a processed sheet in a single cure technique. The bond strength between the lining and the acrylic resin is not good, this being especially so if the Plastupalat sheet needs to be markedly deformed to conform to the residual ridge. Its other great weakness is its low abrasion resistance. On account of these two disadvantages, the use of this material cannot be recommended other than on a temporary basis.

*Silicone Products.*—The low water absorption of the silicone rubbers would seem to commend their use in the mouth. Unfortunately, their high processing temperatures and high linear contractions have so far mitigated against their use. At the present time, a low temperature curing silicone rubber has been produced, but this unfortunately contains a lead catalyst. The future development of these products should be carefully assessed in the hope that a silicone rubber might yet find application in dentistry.

One proprietary product* has been used with only some success. Its high bond strength to acrylic resin makes it particularly useful in those dentures where unsupported resilient flanges are used to engage bilateral undercuts. The processing technique is simple, but, unfortunately there is some loss of material from the surface in use, and it does tend to swell markedly. Flexibase has recently become available. Ten patients with this material in dentures are under survey, and early inspections seem encouraging. The advantage of this material is the ease of technique.

## THE USE OF PHYSICAL TESTS

As a result of examining the shortcomings of several different soft resins in the mouth, it is felt that tests for the following physical properties might be useful in assessing the probable behavior of these materials: (1) abrasion resistance, (2) hardness, (3) water absorption, and (4) bond strength to acrylic resin or other suitable denture base.

*Abrasion Resistance.*—It is probably easier to define abrasion resistance indirectly; it is the reverse of abrasion loss, which is the volume of resilient resin

*D. P. Veldent.

abraded from a specified test piece when subjected to abrasive wear under specified conditions. The purpose of such a test is to make *laboratory* comparisons.

A modified form of the DuPont test has been found applicable to the testing of resilient denture base resins (Fig. 7). Essentially, the apparatus consists of a rotating abrasive disk, 17 cm. in diameter, against which two test pieces of the concerned material are held under a forced load. The disk takes the form of a circular abrasive sandpaper of fine grade, which is changed on the completion of each test. The abrasive particles are cleaned by directing a compressed air blast over the surface of the disk; two such jets may be seen in Fig. 7 situated between the horizontal beam of the apparatus which serves to hold the test pieces. The test pieces are made in a steel mold and have a square face of $2 \pm 0.5$ cm. side. The thickness of the specimen is approximately 1 cm. and two extensions are present on the base of this to effect a locking to the horizontal beam of the apparatus. A circular steel rod extends horizontally and perpendicularly from the beam and

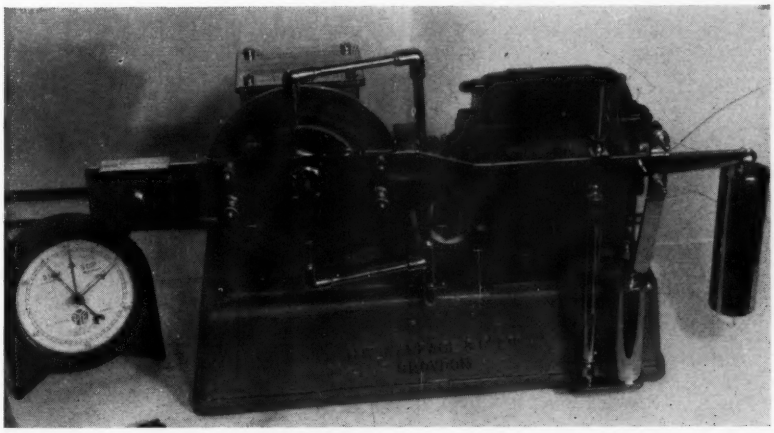

Fig. 7.—The DuPont abrasion tester.

traverses through a tubular bearing situated on the center of the rotating abrasive disk. A constant weight of 8 lb. (3.62 Kg.) is suspended from this rod over a pulley to ensure the application of the square face of the test piece under fixed load against the abrasive disk. The horizontal beam is balanced by addition of lead shot to the container at its extremity and by the adjustment of tension in the spring so that when the disk rotates at a speed of 34 to 40 r.p.m. the beam effects a synchronous up-and-down movement about the axis rod over a specific range of distance. This assures a more even abrasion of the test specimens during the test. The abrasion loss is measured as volume of soft resin lost per hour, and comparisons can be made between the different experimental materials. One material (Jospi) has been too soft for the standard degree of abrasive disk recommended, thus giving unsatisfactory results; in the mouth, it showed marked loss of surface material with rippling. Of those tested, polyvinyl chloride with dibutyl phthalate as the plasticiser showed the least volume loss (570 to 620 c.c. per horse power

hour). Provinyl-p.Ultra, one of the most satisfactory materials to date clinically, showed a loss of 1,600 c.c. per horse power hour.

*Hardness.*—The measurement of hardness is based on the magnitude of the penetration of a rigid bar of known weight into the standard test piece.[7] This is processed in a cylindrical steel mold and the specimen has a thickness of 0.8 to 1.0 cm. and a diameter of 5.12 cm. The hardness is expressed in British Standard degrees, the limiting values of this scale being 0, for a material with a modulus of elasticity of infinity.

Fig. 8.

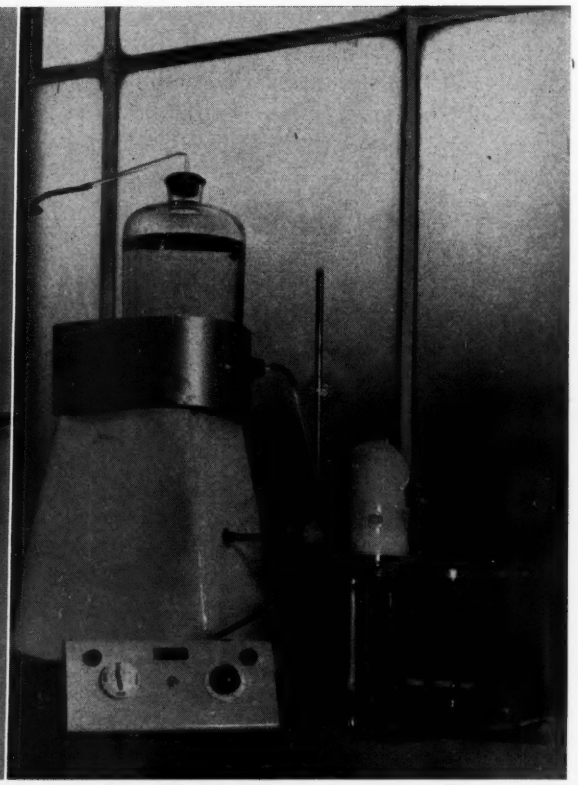

Fig. 9.

Fig. 8.—The hardness tester.

Fig. 9.—An apparatus designed to submit specimens to a continuous flow of water held at body temperature by means of a thermostatically controlled electric immersion heater.

The apparatus used for the test is shown in Fig. 8. The cylindrical test piece is placed on the glass table which is electrically vibrated when the hardness measurement is being taken. The weighted testing rod is racked down under light manipulation of the thumb screw until a resistance is met; this position indicates contact of the rod with the upper surface of the test piece at theoretically zero load. The rotating dial of the hardness gauge is set so that the radical pointer indicates 100 value. The vibrator is turned on, and the weight is lowered into the test specimen. The depth of the depression is measured as degrees of hardness of the specimen.

Since the purpose of a hardness test applied to soft denture resins is to assess their probable behavior when exposed to water for extended periods, measurements of hardness are carried out before and at regular intervals during immersion in water. In this way, comparisons can be made between different soft resins with regard to change in hardness.

To facilitate this condition, a storage tank with water being constantly changed at a steady rate has been designed (Fig. 9). Moreover, the water in the tank is perpetually held at body temperature by means of a thermostatically controlled electric immersion heater. The specimens used in the test may be seen in Fig. 10 as they rest on three vertical wire pins. This ensures free circulation of the water and exposure of all surfaces of the specimen to its action. Specimens are also being immersed at a constant temperature in different solutions, such as distilled water, normal saline, and lactic acid.

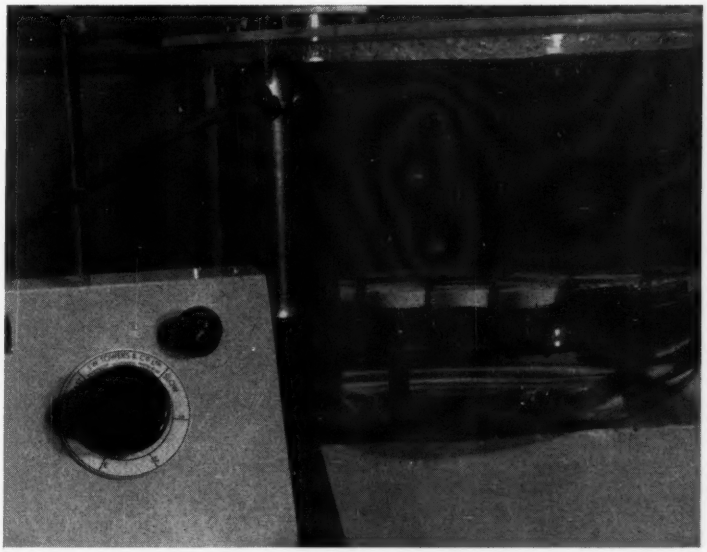

Fig. 10.—Specimens in the storage tank are seen supported by three pins to allow free circulation of the water and exposure of all surfaces.

The specimen of Provinyl-p.Ultra immersed in lactic acid displayed cracking at the point where a retaining pin was attached; this cracking was similar to that seen with this material in the mouth. The specimen of Provinyl-p.Ultra in the water tank did not show hardening, but the polyvinyl chloride plasticised with dibutyl phthalate increased from 36 degrees to 64 degrees over the 18-month period. The other materials showed varying increases but none so great as polyvinyl chloride.

*Water Absorption.*—The water absorption of a soft denture resin may be expressed at the weight or volume of water absorbed into the material expressed as percentage of the "net" volume of the test piece (total volume less the volume of matter extracted by the water[7]).

The specimens used in this test are again cylindrical in form having a volume of 1.0 ml., a diameter not greater than 2.5 cm., and a thickness not greater than 0.6 cm. This specimen is weighed in air ($W_1$) then immersed in water in a weighing bottle ($W_2$), care being taken to remove all air bubbles. After regular periods of immersion in the water bath described above, weighings are again taken in fresh water ($W_3$) and after are dried in a tapered weighing bottle ($W_4$).

$$\text{The swelling, } Sv = \frac{(W_4 - W_3) - (W_1 - W_2)}{W_1 - W_2} \times 100$$

Polyvinyl chloride has shown a tendency to become saturated with regard to water absorption after a period of approximately four months. The other materials show a more continuous but small imbibition.

Physical tests for the degree of bond strength to acrylic resin or other suitable denture bases are being developed.

SUMMARY

In this preliminary report on resilient denture plastics, the indications for the use of these materials and the desired physical properties are discussed. Results of a clinical survey are given. A number of physical tests have been described.

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## A STONE TOOTH DENTURE

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Denture teeth have been fabricated from a great many materials including ivory, metal, silver, porcelain, and acrylic. To the best of our knowledge the only denture possessing beach stone teeth is on display in the prosthetics museum at Tufts University, School of Dental Medicine with the following explanation:

Haverhill, Mass.
Feb. 19, 1948

Tufts College:

Dear Sirs. The vulcanite upper denture, using beach stones for teeth, was made about fifty years ago by Walter H. Pierce, D.D.S., born in Pittsfield, N. H. in 1867, graduated from Boston Dental College.

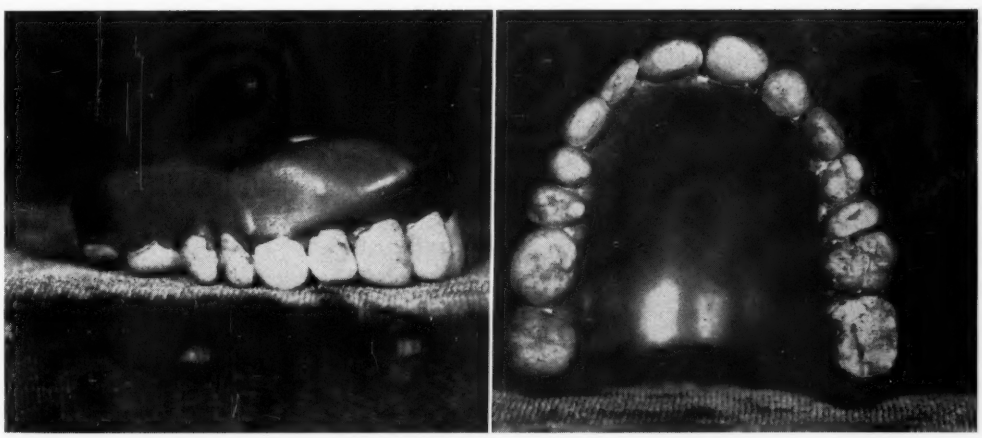

Fig. 1.

This denture is a practical case, and worn by him, with natural lower. It was repaired in 1938, with small stone lateral from Rye Beach. Dr. Pierce died in Pittsfield in 1936.

Yours truly,
George Madison Bunker

136 Harrison Ave.
Boston 11, Mass.

Received for publication May 16, 1957.

## *REMOVABLE PARTIAL DENTURES*

# THE BIOMECHANICS OF REMOVABLE PARTIAL DENTURES AND ITS RELATIONSHIP TO FIXED PROSTHESIS

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THE DESIGNING AND CONSTRUCTION of removable and fixed partial dentures present numerous biomechanical problems. The purpose of this article is to review some of these problems and to clarify the engineering principles associated with them.

Unfortunately, too many dentists fail to undertake a study of the individual case to determine what the design and treatment should be. It is the responsibility of the dentist to design each restoration and to instruct the laboratory technician as to the design indicated. These instructions should include designation of the teeth to be utilized to receive attachments and the types of attachments to be used. No lack of respect for the ability of the dental laboratory technician is implied, for we recognize the importance of this highly skilled auxiliary assistance.

When planning and engineering a mouth rehabilitation, the dentist should give primary consideration to saving the remaining tissues of the oral cavity, both the nonresilient (the teeth) and the resilient (the mucosa and underlying bony structures). If this is done conscientiously, the successful replacement of the missing teeth can be readily accomplished.

### DIAGNOSIS

Diagnosis is one of the most important phases of dentistry. If it is neglected, failure can be anticipated in any procedure, whether it be in operative dentistry, surgery, periodontics, or complete or partial denture prosthodontics.

In removable partial denture diagnosis, it is not sufficient merely to look into the patient's mouth and, after noting the missing teeth, proceed with treatment. Before work is started for any patient, complete mouth roentgenograms and accurately mounted study casts should be obtained. Study should determine (1) the necessary operative dentistry to be done before partial dentures are constructed,

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(2) the presence of periodontal lesions and their treatment, (3) the length of the roots and the bone level support of abutment teeth, and (4) the type of attachments indicated (whether internal or external).

If the abutment teeth show bone loss or a degree of mobility which would prevent them individually from assuming the burden of support and bracing of the appliance, then they should be tied together by either gold castings or fixed partial dentures.

### INTERNAL ATTACHMENTS

Many of the teeth to be used as abutments or to receive retainers need operative treatment. When such is the case, the use of internal attachments should be considered. The dentist then has an ideal opportunity to place internal attachments within the restorations required by the abutment teeth for their protection and function.

The use of internal attachments is desirable where they can be used because (1) forces upon the abutment teeth are brought closer to the center of the teeth than with external attachments, (2) stresses applied to the abutment teeth are applied closer to the bony support of the teeth than with external attachments, (3) an internal attachment protects the abutment tooth from the lateral movements, and (4) internal attachments improve esthetics by eliminating unsightly clasp arms.

### EXTERNAL ATTACHMENTS

If the abutment teeth are in excellent condition, without old fillings or inlays that have outserved their usefulness, and if the treatment of choice involves the use of external attachments, study casts should be made and surveyed first. This procedure will often disclose unfavorable survey lines (excessive tooth contours). These excessive tooth contours can be improved for clasping by grinding and reshaping the teeth. The tooth surfaces are first modified on the study casts, and the cut surfaces on the cast are marked with a red pencil. With the study casts as a guide, the excessive tooth contours on the patient's natural teeth are then reduced. The location, design, and depth of occlusal rests should also be ascertained and ground on the study casts before they are cut into the patient's abutment teeth. Such care in treatment planning may determine the success or failure of the treatment.

### OCCLUSION

When the mandible closes into its centric relation or terminal hinge position, a skid may be observed if deflective occlusal contacts are present between the opposing teeth. The necessary occlusal correction should be done by very careful and painstaking selective grinding. The dentist should do a great deal of study and be very careful in his procedures when attempting to correct the occlusion by grinding. Deflective occlusal contacts in eccentric positions of the mandible should be corrected before partial dentures are constructed, as oftentimes the absence of teeth over a period of time without replacement causes or permits movement of the patient's remaining teeth.

Missing anterior teeth should be replaced with fixed restorations whenever possible. Their placement on a removable appliance, in conjunction with posterior tooth replacement, may create an anteroposterior tilting of the appliance. This could result in a severe destructive force upon the supporting stuctures of the abutment teeth.

Whenever an anterior tooth is to be used to receive a retainer, a casting should be made to receive a definite dowel rest. This is important because of the alignment and tapering shape of anterior teeth. This procedure will eliminate the possibility of destructive forces on the teeth and aids in directing stresses parallel to the long axis of the abutment teeth.

### BIOMECHANICS

The primary biomechanical principles to be considered are support, bracing, and retention. Both the nonresilient and the resilient types of tissues are used to accomplish these principles. Nonresilient support against vertical forces can be accomplished by the use of occlusal rests, dovetail rests cut in inlays, crowns, etc., Kennedy bars, or internal attachments. Resilient support can be accomplished by the use of large denture bases and by complete coverage of the surface of the hard palate. Too often dentists are influenced by their patient's desires to use a palatal bar where more complete coverage of the palate is indicated.

### BRACING AND RETENTION

Bracing against lateral forces is probably the most important of the biomechanical principles. When the mandible moves from its centric position to an eccentric position, a powerful lateral force is exerted against the appliance which is transmitted to the abutment teeth. To minimize this force, a noninterfering functional occlusion should be developed.

Nonresilient bracing is accomplished by the use of rigid clasp arms above the height of contour, occlusal rests, dovetail locks in inlays, crowns, etc., and internal attachments. Resilient bracing can be accomplished by the use of large and deep denture bases.

### RETENTION AGAINST DISLODGMENT

Retention against dislodgment is possibly the least important of the biomechanical principles. Removable partial dentures should not fit tightly on the hard tissues. There should be enough retention to prevent the displacement of the maxillary denture by gravity and the dislodgment of the mandibular denture by sticky food.

Nonresilient retention is accomplished by the use of clasp arms below the height of contour and by snubber arms which are constructed when a dowel attachment is used. Precision attachments retain a removable partial denture only when the length of the clinical crown permits the utilization of the entire length of the attachment. The only retention provided by a precision attachment is that of a frictional grip between the male and female portions of the attachment. Therefore,

length of the attachment is of paramount importance. Lingual snubber arms may be added to precision attachment partial dentures for supplemental retention.

Resilient tissue retention can be accomplished by tissue coverage and tissue adaptation. This should be accomplished in the partial denture impression.

### OCCLUSAL RESTS

Occlusal rest seats should be cut at right angles to the long axes of the teeth. They should be spoon-shaped and wide enough to distribute the force upon the abutment teeth. They should be smooth and highly polished. Ideally, the enamel of the tooth should not be penetrated, but if this occurs, an inlay should be placed in that surface. If occlusal rest seats are not cut at right angles to the long axes of the teeth, the rests will exert a wedging effect upon the abutment teeth and they will be a contributing cause to the breakdown of the investing tissues. The rests should be thick enough to be strong and rigid enough to prevent breakage.

### SOFT TISSUE COVERAGE

In many maxillary removable partial dentures, the outline form of the arch is the form of choice. This form gives a degree of tissue coverage which provides a high degree of support to the appliance, since the most resorption of bone occurs on the residual ridges and not in the rugae area. The incisive papilla should never be covered by the denture base as this structure should be exposed to the tongue, and the denture base would be annoying to the patient.

The free gingivae are nonsupporting structures, and the appliance should not impinge upon these delicate tissues. If it does press upon them, pathologic conditions may develop in them. Care must be taken to avoid impinging upon this tissue where the minor connectors extend from the framework to the occlusal rest or clasp.

Positioning the teeth over the ridge not only helps to stabilize the denture but it also places less strain upon the abutment teeth. It is often desirable to reduce the buccolingual diameter of the artificial teeth and to place them on as large a denture base as the anatomic structures will permit. This reduces the load encountered in function and distributes it over a larger area.

### KENNEDY BARS

When the Kennedy bar type of indirect retainer is used, its correct placement is of importance. It should be placed *directly on* the cingulum and not above or below it. It should be teardrop in cross-section shape to keep food clear of the free gingivae, thus protecting that delicate tissue. If the Kennedy bar is placed above the cingulum, the partial denture will act as an orthodontic appliance and move the teeth it rests against.

### APPLIANCE RIGIDITY

Removable partial dentures should be rigid. Cast lingual bars should be as wide as possible. They should not be flimsy in construction or have any springing

or bending action. This is true also for palatal bars and arch-shaped castings. Because of its lack of rigidity, the average contoured lingual bar is inadequate for most removable partial dentures.

### ABUTMENT CASTINGS AND FIXED PONTICS

Most abutment castings for both fixed and removable partial dentures should include the complete coverage of cusps. Many failures result from the lack of cusp coverage. The impact of occlusal forces upon the inlay margins may cause a breakdown of the enamel rods and the ultimate failure of what had previously been a well-fitting abutment casting.

The use of high-fusing and highly glazed porcelain pontics against the tissues has given great satisfaction. The use of plastic fixed pontics against the soft tissues should be condemned. Where there is a lack of vertical space and porcelain pontics are likely to break, a highly polished rhodium-plated gold pontic is far superior to a plastic pontic.

Where esthetics is important, a plastic facing can be heat-cured into the gold pontic or into the buccal surface of a cast crown. These commercial plastic facings are made of a material far superior to that which can be processed in the average dental office.

### SUMMARY

Clasps will always be used for attachments for removable partial dentures. However, they have many disadvantages and possible destructive effects, some of which follow:

1. Caries may develop around and under clasp arms. This develops particularly when the patient fails to keep the appliance clean.
2. Strain is placed on the abutment tooth. A clasp as an attachment imparts a heavier load to the abutment tooth than an internal attachment. The forces applied by the clasp are not as nearly vertical as they are when an internal attachment is used.
3. The occlusal rest is likely to be weak.
4. Clasps have poor esthetics and leave much to be desired from an esthetic point of view.
5. Internal attachments tend to save abutment teeth for a longer period of time than do external attachments.

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# OCCLUSAL RESTS AND REST SEATS

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OCCLUSAL RESTS ARE INSIGNIFICANT in appearance and size when compared to a completed partial denture. Yet their usefulness is of major importance in maintaining that denture and its supporting teeth in proper biomechanical function and health. Occlusal rests together with clasping devices perform for removable partial dentures the same functions that abutment attachments serve in fixed partial dentures.

An occlusal rest consists of two component parts—a horizontal portion and a vertical portion. The horizontal portion is that part which rests on the abutment tooth and transmits the forces of mastication to the tooth. The vertical component connects the horizontal part of the rest to the partial denture base.

A rest seat is the prepared site on an abutment tooth which will accommodate an accurately fitting occlusal rest. The rest site may be prepared in a sound tooth or in a restoration on a repaired tooth.

## OCCLUSAL REST FUNCTIONS

The functions of an occlusal rest are:

1. *To direct the forces of mastication parallel to the long axis of the abutment tooth.* For this to be accomplished, the horizontal portion of the rest must be at right angles to the long axis of the abutment tooth or be inclined slightly toward the center of the tooth.

2. *To act as a stop, preventing injury and overdisplacement of the soft tissues under partial denture bases.* In free-end partial dentures, this stop action takes place mainly in the region approximating the abutment teeth.

3. *To maintain the clasp, which is usually attached to the occlusal rest, in its properly surveyed position.* This prevents the settling of the denture base.

4. *To function as an indirect retainer in a free-end denture base partial denture.* This is especially true when additional rests are placed anterior to the axis of rotation of the partial denture.

5. *To help maintain the partial denture in position.* This is done when the rests contact or occlude with opposing teeth during mastication and deglutition.

6. *To transmit to the abutment teeth some of the lateral forces applied to the partial denture during mastication.* This action is increased by deepening the rest seat.

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7. *To prevent impaction of food between the clasp and the proximal surface of the abutment tooth.*

8. *To close a small space between teeth by bridging that space with occlusal rests* (Fig. 1).

9. *To act as a rigid reciprocal arm of a retaining clasp.* This function is most pronounced when the rest is set into a tapered box-lock seat in a gold crown or inlay. When a rest is utilized for this purpose, the lingual clasp arm acts with the rest to provide the retention, thereby eliminating an unsightly labial or buccal clasp arm.

10. *To build up an abutment tooth with a large occlusal onlay rest.* This is necessary if there has been a loss of occlusal contact due to the drifting of teeth (Fig. 2).

11. *To prevent extrusion of abutment teeth.*

Fig. 1.

Fig. 2.

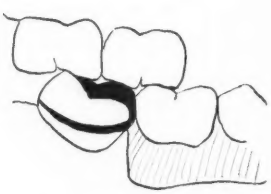


Fig. 1.—A small space between two teeth may be bridged by connected occlusal rests.
Fig. 2.—Occlusion may be restored by the use of a large onlay rest.

## PLANNING THE OCCLUSAL REST

Of the many causes for partial denture failure, poor planning, design, and placement of occlusal rests deserve special consideration. To avoid failure, the treatment must be thoroughly planned in advance by careful observation of study casts. In planning partial dentures, the following questions relating to occlusal rests and occlusal rest sites must be considered:

1. Which teeth should bear occlusal or incisal rests?

2. How much grinding of tooth structure will be necessary to accommodate the occlusal rests?

3. How much grinding of the occluding teeth will be necessary to provide additional clearance for the rests?

4. How much reduction of tooth contour on the proximal surfaces of teeth bearing occlusal rests will be necessary? The contour should be reduced so that the vertical portion of the occlusal rest may be constructed as close to the tooth as possible. Thus, unsightly embrasures and food traps between the vertical connecting member of the occlusal rest and the proximal surface of the abutment

tooth are eliminated (Fig. 3). Other contours of the abutment tooth should be reduced slightly to allow the survey line for the clasp to be moved toward the gingival third of the tooth. The labial clasp arm is less visible in this position, and traumatic leverage on the abutment tooth is reduced.

5. Will it be necessary to restore the abutment tooth, and, if so, what type of rest seat will be prepared in the finished restoration? Teeth that are badly decayed or that contain large amalgam fillings should be restored by the use of full or partial gold veneer crowns. The use of amalgam as a base for an occlusal rest should be avoided, if possible. If the economic factor is a consideration, amalgam may be used to correct defects in the enamel at the proposed rest positions. Due to the inherent weaknesses of amalgam, the rest positions in this material should be broad and saucer-shaped, rather than narrow and deep. A rest of greater diameter will be less likely than a small one to abrade or fracture the amalgam filling upon which it is placed.

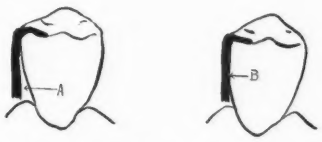



Fig. 3.—The vertical connecting component of the occlusal rest should be constructed close to the proximal surface, *B*, by reducing the tooth contour, thereby eliminating the wide embrasure shown at *A*.

## CLASSIFICATION OF OCCLUSAL RESTS

Occlusal rests may be classified according to the type of surface against which they are placed: (1) rests contacting natural tooth structure in (a) anterior teeth, and (b) posterior teeth; and (2) rests constructed in gold restorations.

## OCCLUSAL RESTS ON NATURAL TOOTH STRUCTURE

The incisal rest in an anterior tooth contacting natural tooth structure must direct the forces of mastication in the direction of the long axis of the tooth. Therefore, the rest must be placed on the incisal edge of the tooth. Any rest which is placed on the inclined lingual surface of an anterior tooth will doom that tooth to quick destruction by forcing the tooth in a labial direction. The incisal rest seat is prepared by grinding a right angle step into the incisal corner of the tooth to a depth of 1.0 mm. and a width of 1.0 to 1.5 mm. (Fig. 4). The horizontal cut should be inclined slightly downward toward the center of the tooth.

Rest seats should not penetrate into the dentine. However, the exposure of dentine is often unavoidable when rest seats are prepared in abraded teeth. In this situation, the danger of caries may be minimized by careful polishing of all cut surfaces, beveling of enamel edges, and the application of caries-inhibiting agents. The importance of good oral hygiene should be impressed upon patients with rest seats prepared in natural tooth structure.

A type of rest seat which is applicable, especially to the cuspid, involves the mesial and distal corners of that tooth. These corners are ground off at a 20° angle to a perpendicular line projected through the long axis of the tooth (Figs. 5 and 6). The small facets thus produced become the rest-bearing areas for a rigid lingual arm of a reciprocally acting labial arm clasp.

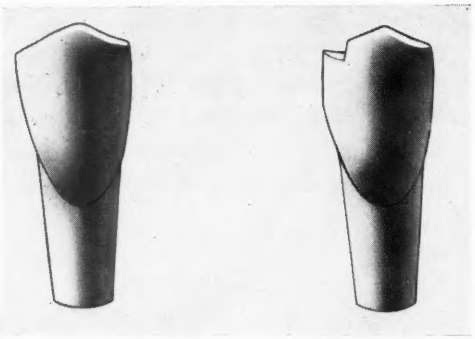


Fig. 4.—The preparation of a lower cuspid for an incisal rest. Note that the rest seat is inclined so as to direct the forces of mastication parallel to the long axis of the tooth.

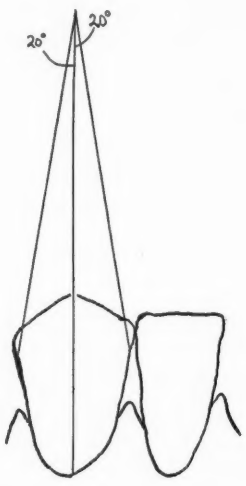
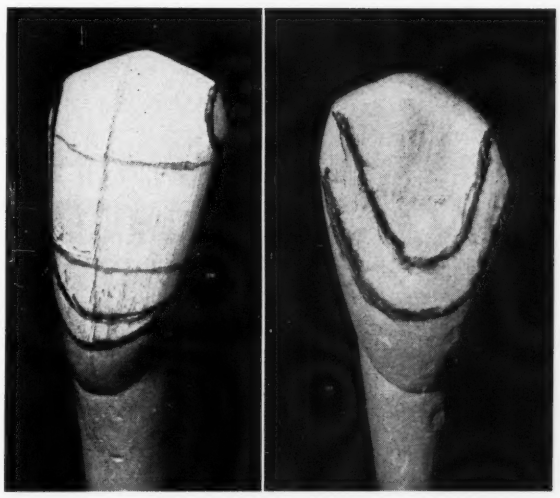



Fig. 5.—The correct angulation for grinding rest-bearing facets on a lower cuspid.

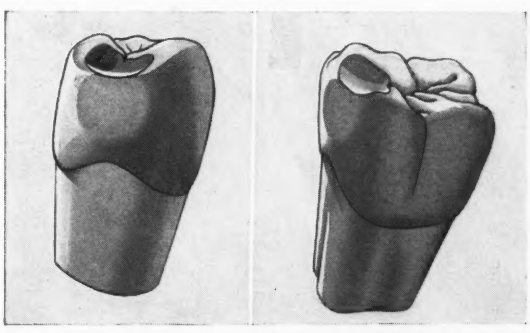
Occlusal rest seats for posterior teeth contacting natural tooth structure are saucer-shaped and are made at right angles to the long axes of the teeth, or they may be inclined slightly toward the long axis of the tooth (Fig. 7). They are prepared by using round or pear-shaped diamond instruments, or mounted Carborundum points. Marginal ridges are reduced sufficiently so that the occlusal rests will have their greatest thickness and strength at the junction of their ver-

tical and horizontal components. The opposing tooth may also be ground to provide extra clearance for the rest. The size of the rest seat depends on the size of the tooth. In general, it should be from 2 to 2.5 mm. in diameter. An onlay rest that covers the entire occlusal surface of a tooth may be used to correct a deficiency in occlusion (Fig. 2). The normal occlusal anatomy of the tooth may be carved on the occluding surface of this type of rest. However, onlay rests should never be used on unprotected teeth of caries-susceptible patients.



*A.* *B.*

Fig. 6.—Rest-bearing facets prepared on a lower cuspid. *A*, Labial view. *B*, Lingual view. Note the outline of the rigid lingual clasp arm.



*A.* *B.*

Fig. 7.—Occlusal rest preparations on posterior teeth. *A*, Proximal view. *B*, Buccal view. Note the inclination of the rest seats and the reduction of the proximal contour.

## OCCLUSAL RESTS ON METAL RESTORATIONS

Rest seats may be prepared in gold restorations in abutment teeth by using the same techniques as for those in tooth structure. However, other types of rest

seats may be prepared in gold restorations and these are limited only by the mechanical ingenuity of the dentist. The rest seats vary in size, shape, depth, and placement on the restorations. Rest seats may be prepared in gold inlays, full or partial veneer crowns, or on porcelain baked-to-platinum restorations. When an anterior tooth crown is waxed and carved to receive a rest, the lingual surface of the wax is recontoured to permit the rest to convey the forces of mastication in the direction of the long axis of the tooth. An effort must be made to shape the crown so that the rest seat is located near the gingival third of the tooth in order to reduce the leverage on the abutment tooth. A rest seat position on a restored anterior tooth may be prepared by accentuating the cingulum when the wax pattern is carved. The elevated cingulum will cradle the rest and properly distribute the forces of mastication (Fig. 8). The rest used in a seat of this type may also serve as a rigid lingual arm of a clasp.

When the thickness of gold in crowns is sufficient, tapering box-lock rest seats may be prepared (Figs. 9, 10, and 11). These box-lock rest seats are best prepared in crowns or inlays after they have been transferred from the mouth to master casts by suitable impression techniques. If several of these rest seats are to be used for a partial denture, parallelism of the rest seats is essential. The box-lock is ground into crowns by using tapered fissure burs mounted in a handpiece jig on a surveyor. Tapering box-lock rests require only properly executed lingual clasp arms to provide retention for the partial denture. Tapering box-lock rests may be used on either anterior or posterior teeth. A major disadvantage in the use of this type of rest is the necessity for the removing of extra tooth structure in order to provide the necessary thickness of gold to accommodate the box-lock rest.

If excessive grinding of the tooth is not advisable, a hook-type of rest seat may be used. This type of rest seat requires a minimal thickness of gold, and it may be placed anywhere on a cast three-quarter or full-crown that design of the partial denture dictates. The position of choice for the rest seat should be as close to the gingival third of the tooth as possible, in order to reduce leverage on the tooth and to allow for the inconspicuous placement of the buccal clasp arms (Figs. 12, 13, 14, and 15).

## TROUBLE-SHOOTING ILL-FITTING RESTS

Occlusal rests must fit their respective rest seats on the abutment teeth with precision if they are to perform their many functions. Often the component parts of a partial denture fit the master cast accurately but will not fit in the mouth with the same degree of accuracy. Some of the same factors that produce ill-fitting abutment castings in fixed partial dentures will result in ill-fitting rests in removable partial dentures.

Poor impression and duplicating techniques cause castings not to fit. Moisture and saliva on prepared abutment teeth will cause defects in impressions made with hydrocolloid or rubber base impression materials. The importance of drying prepared abutment teeth is of paramount importance to secure accuracy of fit in making fixed restorations. The same precaution applies to impression tech-

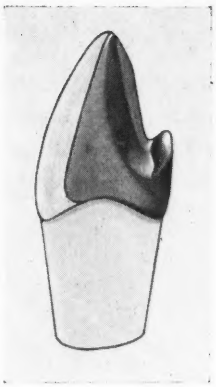


Fig. 8.

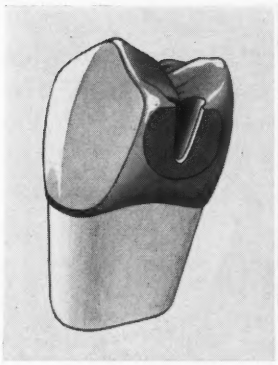


Fig. 9, *A*.

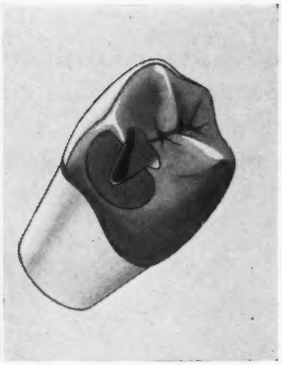


Fig. 9, *B*.

Fig. 8.—The lingual surface of a cuspid is recontoured by means of a restoration to form a rest seat.

Fig. 9.—Tapered box-lock rest seats in acrylic resin veneer crowns. *A*, Distobuccal view. *B*, Distolingual view.

Fig. 10.

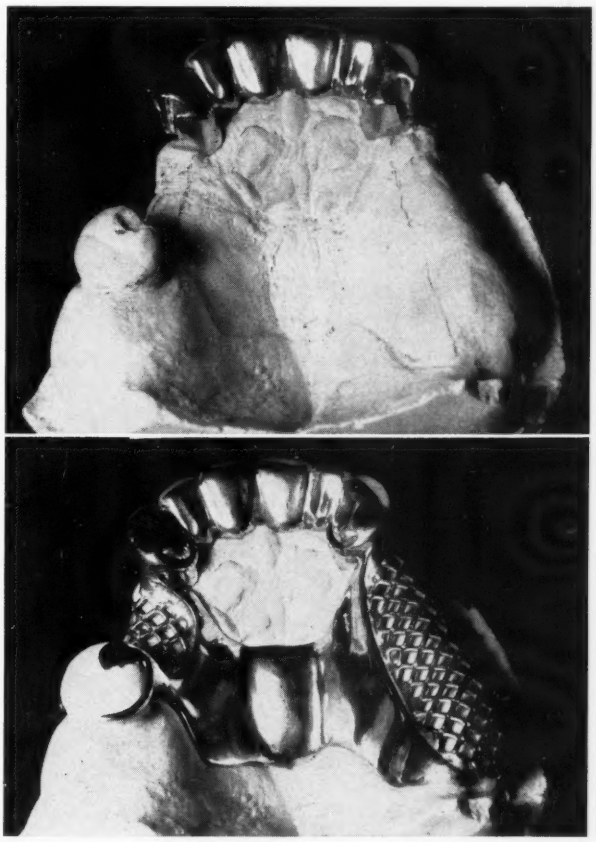


Fig. 11.

Fig. 10.—Tapered box-lock rest seats in cuspid acrylic resin veneer crowns which are splinted together on the remaining anterior teeth.

Fig. 11.—The partial denture framework in position. The lingual clasp arms provide adequate retention when they are used with tapered box-lock occlusal rests.

niques used for removable partial denture work. If thick ropy saliva is trapped between the rest site and the impression material, the inaccuracy may not be apparent until the casting is tried in the mouth. Movement of the impression tray while the impression material is setting will also cause defects that are difficult to detect at this stage of the construction.

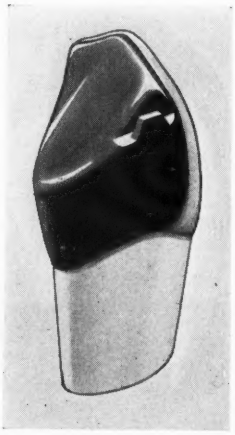
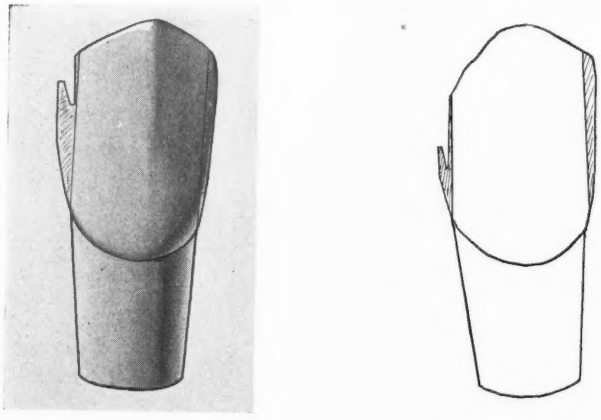


Fig. 12.—A hook rest seat in a three-quarter veneer crown on a cuspid.



*A.* *B.*

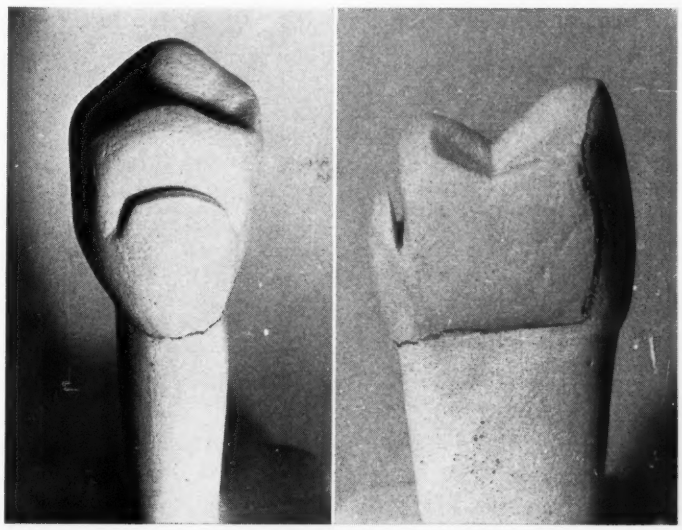
Fig. 13.—*A*, A hook rest near the incisal edge. *B*, A hook rest seat constructed near the gingival third of a cuspid three-quarter veneer crown. Note the small amount of natural tooth structure removed and the minimal thickness of exposed gold.

Mishandling of the master and refractory casts will cause castings not to fit. The casts used in removable partial denture construction deserve the same careful handling as those used in fixed partial denture construction. Rubbing and chipping of casts introduce avoidable inaccuracies.

Excessive polishing of the occlusal rests on the metal framework will cause them not to fit. Grinding and polishing of the undersurfaces of rests should be kept to a minimum to assure accuracy of fit.

Despite all precautionary measures taken to assure accuracy, poor fit of a rest may occur. Often an interfering high spot on the underside of the rest can

Fig. 14.—A variation of the hook rest seat in a cuspid three-quarter veneer crown.



*A.* *B.*

Fig. 15.—A hook rest seat in the lingual surface of a bicuspid three-quarter veneer crown. *A*, Lingual view. *B*, Proximal view.

be found and relieved so the rest will seat properly. To locate the interfering part, the underside of the rest is sand-blasted to give it a satin finish. Then the denture is placed in the mouth and pressed firmly into position and removed. Upon removal from the mouth, the sand-blasted area is inspected for bright burnished spots which denote interfering high points. These high spots are meticulously ground away. This procedure may be repeated until the partial denture is fully seated.

Finely divided carbon is deposited on the underside of the rest by burning a pledget of cotton which has been dipped in eugenol. The occlusal rest is held above the flame, and the dense carbon smoke will coat it. The denture is then tried in the mouth and removed. The interfering points are those points where the carbon has been rubbed off. This reveals the prematurely contacting portions of the rest.

In some instances, a rest does not contact its rest seat at all, even though the remainder of the partial denture goes into place. This rest may be refitted by burnishing a small piece of 0.001 platinum foil to the rest seat in the tooth. The denture is then seated, and the platinum foil is sealed to the rest by painting a mix of quick-setting acrylic resin between the foil and the rest. After the acrylic resin has set thoroughly, the denture is removed from the mouth with the platinum foil attached to the rest. The denture is invested, the acrylic resin is burned out, and solder is deposited in its place.

## SUMMARY

Occlusal rests and rest seats deserve special consideration in removable partial denture construction. Proper understanding of the functions, design, and placement of occlusal rests is necessary in planning and producing a successful partial denture. Many remakes may be avoided by being aware of the factors that cause ill-fitting rests and by knowing how to locate and correct rests that do not fit properly.

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# REBASING PROCEDURES FOR REMOVABLE PARTIAL DENTURES

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PARTIAL DENTURE PROSTHESIS IS a much maligned branch of prosthetic dentistry. Considerable attention has been brought to the damage resulting to abutment teeth following the wearing of a partial denture. In some instances, the damage is unavoidable because of unfavorable conditions that do not permit application of the concepts of satisfactory design. In other instances, however, damage may be caused by failure to recognize mouth changes and to institute corrective procedures.

One of the most common mouth changes observed in patients wearing partial dentures is ridge resorption under the saddles (denture bases†). When present, rebasing should be undertaken to restore the relationship of the partial denture to the supporting structures that originally existed. Unfortunately, however, this essential procedure is often avoided or haphazardly performed. A lack of confidence seems to exist as to its ultimate effectiveness. It is felt, many times, that a satisfactory result is unattainable regardless of how well the procedure is performed. This is often true because of a basic failure to recognize the nature of the problem. Many factors are present, and details of procedure are dictated by them. Obviously, a simple all-inclusive technique is not possible. If satisfactory results are to be obtained, different procedures are necessary, depending upon the conditions observed in the mouth under consideration.

The critical factors that determine the rebasing procedure followed are: (1) the type of denture bases present on the partial denture, (2) the degree of ridge resorption under the denture bases, (3) the accuracy of the border extension of the denture bases, (4) the occlusion of artificial teeth on the denture bases, and (5) the presence of framework rotation.

## TYPES OF DENTURE BASES†

Two types of denture bases are found on partial dentures: the free-end base and the tooth-bounded base. The difference is determined by the relationship of the remaining natural teeth (usually abutments bearing rests) to the extremities of the denture base. The free-end base has a natural tooth adjacent to only one of the base

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†The preferred term *denture base* is used in preference to its synonym *saddle* to conform to the terminology recommended in the *Glossary of Prosthodontic Terms*.—Ed.

extremities. This natural tooth is the most posterior tooth remaining in that side of the jaw. The other extremity of the base extends to the posterior limit of the bearing area and is relatively free to move.

The tooth-bounded denture base has natural teeth (usually serving as abutments and bearing rests) on both extremities of the base. Possible tissueward movement of the base extremities is very slight or nonexistent. This type of denture base is often called a tooth-borne denture base.

Each type of base functions differently, and the clinical picture that each presents following ridge resorption is not the same. Different technical procedures are required, consequently, to restore a partial denture to its original efficiency, depending upon the type of denture base present.

### DEGREE OF RIDGE RESORPTION

The degree of ridge resorption that has occurred under a partial denture base will place varying requirements on an impression material that is used to effect a correction. Many times, these requirements will exceed the capabilities and properties of the material. A careful study and analysis of the conditions present must be made so that an adequate impression material may be selected. In addition, a decision must be arrived at as to the most appropriate technique for manipulating the selected material.

### ACCURACY OF BORDER EXTENSION

Very often, a denture base requiring rebasing will not be properly extended. Failure to utilize the available bearing area and properly distribute stresses may have been a contributing cause to the existing ridge resorption. If a repetition of the resorption cycle is to be prevented, underextended denture base flanges must be corrected. Since not all impression materials can build up underextended flanges, this factor will exert an important influence on the selection of an impression material. Therefore, the step of border correction with an appropriate material must be incorporated in the final rebasing procedure.

### OCCLUSION OF ARTIFICIAL TEETH

When ridge resorption occurs under a tooth-bounded denture base, no change in the occlusion of the replaced teeth will follow, provided rests are present on both natural teeth adjacent to the base extremities. On the other hand, a definite change in the occlusion of the artificial teeth will occur following ridge resorption under a free-end type of denture base. The amount of change will depend upon the degree of resorption and the manner in which the abutment teeth are harnessed. A rigid type of retainer design (wide cast clasps, clasps with deep rests, precision attachments) will allow only a small change in occlusal relationships. At first glance, this may appear to be an advantage and a recommendation for this type of design. However, one must bear in mind the fact that, when ridge resorption occurs, a rigid type of retainer induces severe strain and overload of the abutment teeth. Unless corrective rebasing procedures are instituted quickly, or unless extensive abutment

splinting was resorted to in the original treatment planning, irreparable damage to abutments will result.

The use of a less rigid type of retainer design (clasps with shallow rests) permits a greater degree of denture base rotation when ridge changes occur. Because of this, greater discrepancies in occlusal relationships result. This important factor must be considered in any rebasing technique. Many times it is completely ignored, and the corrected partial denture ends up with an unsatisfactory occlusion. Varying steps must be integrated in rebasing procedures according to the magnitude of change in occlusal relationships.

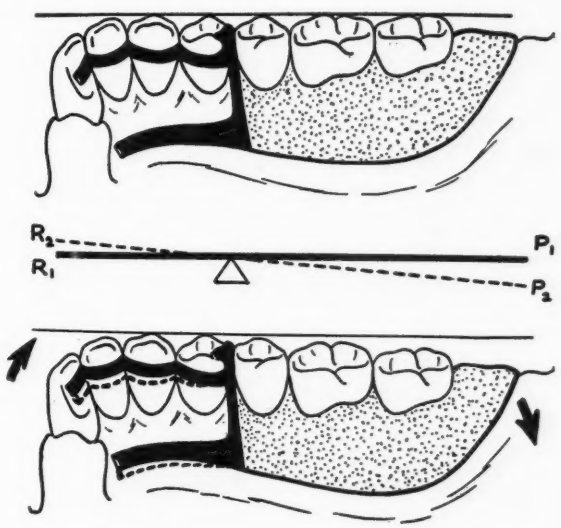


Fig. 1.—Diagrammatic illustration of framework rotation of a free-end partial denture following ridge resorption. *Above*, the original position. *Below*, the new position following ridge resorption and framework rotation. All parts of partial denture posterior to the fulcrum (most posterior occlusal rest) rotate toward the ridges, and all parts anterior to the fulcrum rotate occlusally and posteriorly away from the teeth.

## FRAMEWORK ROTATION

When ridge changes occur under a free-end denture base type of partial denture, a Class I lever system is brought into play. This is the classical see saw lever which has the power and resistance on either side of the fulcrum. As the bases move toward the ridges, all framework contacts that are anterior to the fulcrum axis tend to move occlusally and posteriorly away from their tooth surface contacts (Fig. 1). The fulcrum axis is a line drawn through the most posterior occlusal rests. The amount of rotational movement is controlled by the resorption of the ridges. A disturbance in the relationship of framework to abutment teeth is more evident in those frameworks that are complex and have many contacts a good distance from the fulcrum axis. A satisfactory rebasing procedure must have ways and means of re-establishing the original relationship of a framework to abutment teeth.

The consideration of these five salient factors will dictate the classification of partial dentures requiring rebasing into definite groups. Each group will require modifications or supplements of a general basic technique. The following is a classification of partial dentures requiring rebasing into 7 groups according to clinical observation:

Group I. Tooth-bounded denture bases—slight ridge resorption
Group II. Tooth-bounded denture bases—marked ridge resorption
Group III. Free-end denture bases—slight ridge resorption
Group IV. Free-end denture bases—moderate ridge resorption
Group V. Free-end denture bases—marked ridge resorption
Group VI. Free-end denture bases—excessive ridge resorption
Group VII. Combination of bases of different groups

Obviously, a single rebasing technique is inadequate to handle all of the problems encountered in these groups of partial dentures requiring rebasing. The essential objective of any rebasing technique, as the name implies, is to establish a new basal seat. This basing procedure may be accomplished by any of the free-flowing materials, such as the zinc oxide and eugenol impression pastes and the plasters. Where tissue change is at a minimum, this primary procedure is all that is necessary. However, in partial dentures of groups 2, 4, 5, and 6 where changes are more marked and the relationship of framework to abutment teeth is disturbed, *supplements* to the primary basing technique must be added to the rebasing procedures. Supplements that are added according to changes observed are: (1) border supplement, (2) spacing supplement, (3) framework supplement, and (4) occlusion supplement.

These supplements will be elaborated on when their use is indicated in a description of the procedures required for rebasing a partial denture of each group of the classification.

### GROUP I. TOOTH-BOUNDED BASES WITH SLIGHT RIDGE RESORPTION

When a partial denture having tooth-bounded bases and only slight ridge resorption is encountered, the primary basing procedure is all that is usually required to effect a correction. The occlusal relationships have not been disturbed, and no change in the relationship of framework to abutment teeth has occurred. However, a check must be made on the extension of the flanges of the denture base. If they are underextended, a border supplement must be added to the primary basing technique (Fig. 2). This supplement consists of building up all underextended borders to the correct height and width. Modeling compound is traced on all underextended flanges (Fig. 3), thoroughly heated, tempered, and seated in the mouth. The procedure is repeated until correct border extension is attained (Fig. 4). Prior to making the basing impression, the flanges of the base that are correct and have not been built up must be checked for undercuts. If undercuts are present, they are ground away and then reproduced by adding modeling compound and seating the denture in the mouth. This step is necessary to permit separation of the flask sections during processing. Undercuts in hard, previously processed acrylic resin will not permit separation, and efforts to do so will mar or break the final stone cast.

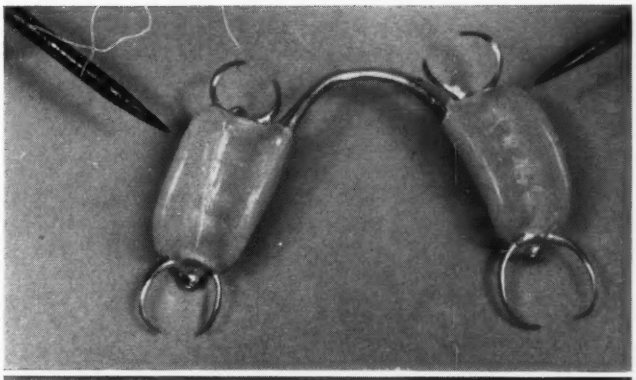

Fig. 2.

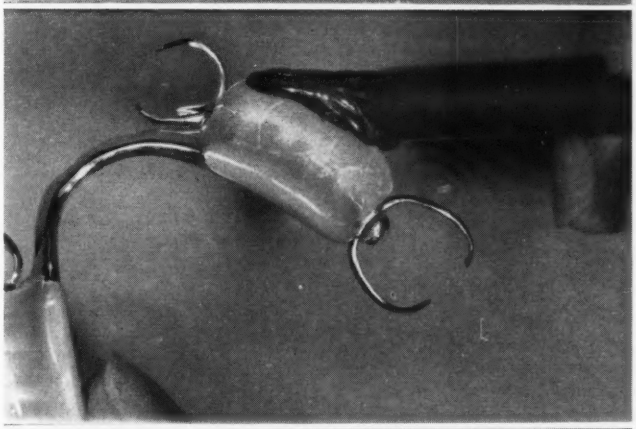

Fig. 3.

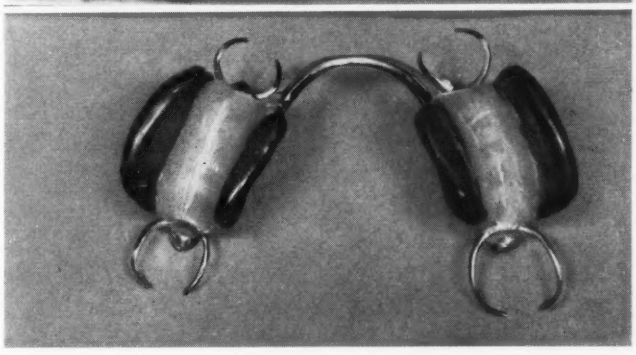

Fig. 4.

Fig. 2.—A partial denture with tooth-bounded denture bases requiring rebasing where only slight ridge resorption has occurred (Group I). The pointers indicate that the borders are underextended, necessitating the addition of a border supplement to the primary basing technique.

Fig. 3.—Stick modeling compound applied to the underextended border.

Fig. 4.—Underextended borders corrected with modeling compound (completion of border supplement).

The final basing impression can be accomplished with a zinc oxide and eugenol impression paste. Care must be exercised in placing the impression material on the undersurfaces of the denture bases. Excess should be avoided, and the paste should be placed about ¼ inch short of the base extremities to avoid its flowing under clasps and rests. After properly placing the paste, the partial denture is carried to the mouth and seated. Firm pressure is applied to the metal framework to make sure that all rests and clasps are properly seated and maintained until the impression material has hardened. The denture is then removed and any excess material that has flowed beyond the confines of the bases is trimmed away with a warmed sharp knife, and the corrected denture is processed (Fig. 5).

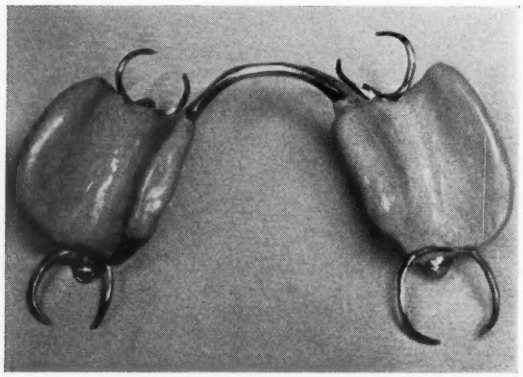

Fig. 5.—The completed basing impression (Group I).

GROUP II. TOOTH-BOUNDED BASES WITH MARKED RIDGE RESORPTION

If marked ridge resorption has occurred under tooth-bounded denture bases, the primary basing impression of zinc oxide and eugenol paste will not be adequate. This type of impression material has little body and can correct only limited discrepancies. To rebase a partial denture in this group properly, a spacing supplement must be added to the general procedure (Fig. 6).

The spacing supplement consists of placing a layer of modeling compound on the inner surfaces of the denture bases to fill up the space that exists between the bases and the resorbed ridges. To permit the free flow of the modeling compound, space for additional bulk is created by grinding away as much acrylic resin material from the undersurfaces of the bases as is possible (Fig. 7). The modeling compound is applied by means of a tracing stick or by means of a thin wafer of sheet compound. The applied modeling compound is thoroughly warmed either by an alcohol torch or by dipping in hot water, and the denture is seated to position. Care must be taken to make sure that the framework is completely seated. If it is not, excess pressure will be developed and this should be avoided; otherwise, displacement of the ridge mucosa results. If complete seating has not been effected, the denture is removed, the compound is reheated, and the denture is reseated. This procedure is repeated until the metal framework is completely seated and the oc-

Fig. 6.

Fig. 7.

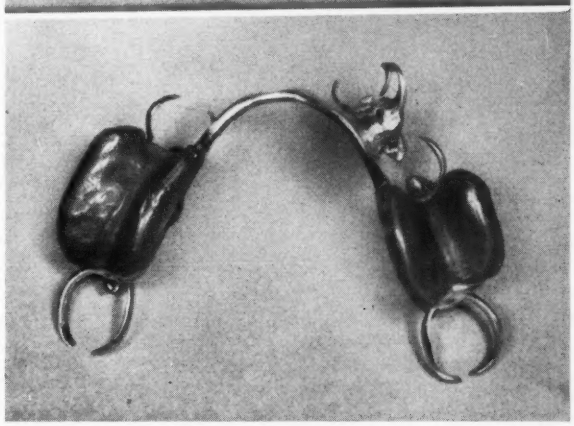

Fig. 8.

Fig. 6.—A partial denture with tooth-bounded bases requiring rebasing where marked ridge resorption has occurred (Group II). The dark pointer indicates underextension of the border and the need for a border supplement. The light pointer indicates a large space between the impression surface of the base and the ridge, and the need for a spacing supplement.

Fig. 7.—The acrylic resin material has been ground away from the impression surfaces of the denture bases.

Fig. 8.—The partial denture with completed spacing and border supplements.

clusal relationships are correct. Any excess modeling compound beyond the confines of the bases is trimmed away. Border extensions are checked. If underextensions are present, the border supplement previously described is added to the procedure (Figs. 8 and 9).

The rebasing is completed by the primary basing procedure. A thin mix of zinc oxide and eugenol paste is placed on the undersurfaces of the modeling compound corrected bases, and the denture is seated in the mouth. Again extreme

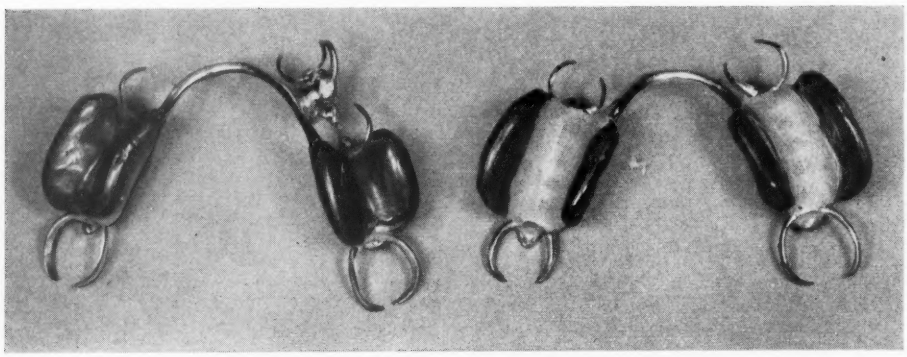

Fig. 9.—Comparison of partial dentures requiring rebasing. *Left*, A partial denture in Group II. The presence of marked ridge resorption requires a spacing supplement in addition to a border supplement before the final basing impression is made. *Right*, A partial denture in Group I. Because of slight ridge resorption, only a border supplement is required before the final basing impression is made.

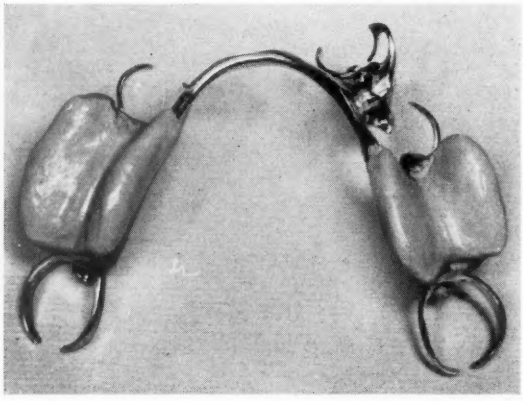

Fig. 10.—The completed basing impression (Group II).

care must be taken to make sure that the framework is properly seated and that the occlusal relationships are not disturbed. Because of the close fit of the base prior to the addition of impression paste, it is easy for an error in the seating of the framework to occur. The zinc oxide and eugenol paste must be of soft, flowable consistency to avoid tissue displacement. The corrected denture is removed, the excess impression paste is trimmed away, and the denture is flasked and reprocessed (Fig. 10).

GROUP III. FREE-END DENTURE BASES WITH SLIGHT RESORPTION

Partial dentures with free-end bases present a greater problem when rebasing is required. The existing occlusion must be observed to detect any change that may have occurred, and the relationship of the framework to the abutment teeth must be evaluated. When slight ridge resorption is present under a free-end partial denture, usually little or no change has occurred in occlusal and framework relationships. Rebasing is indicated because of a lack of stability of the partial denture. A

Fig. 11.

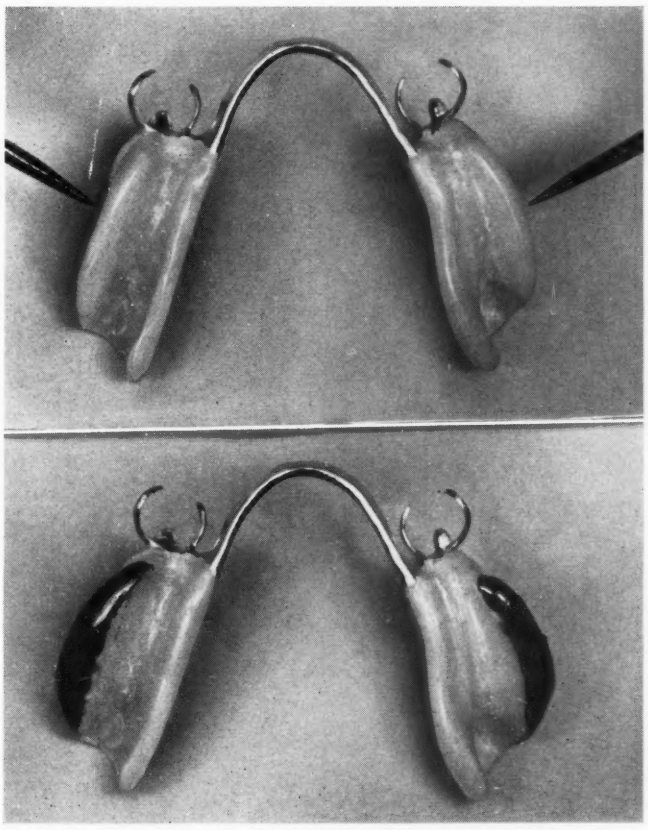

Fig. 12.

Fig. 11.—A free-end denture base partial denture requiring rebasing where only slight ridge resorption has occurred (Group III). The dark pointers indicate underextended buccal flanges and the need for a border supplement.

Fig. 12.—The underextended borders are corrected.

correction of this condition can be effected with the primary basing procedure. However, prior to proceeding with the primary basing procedure, a check must be made of the border extension of the bases and for the presence of undercuts in the bases. If any borders are underextended, a border supplement is required (Fig. 11). As previously described, the border supplement consists of building up the underextended borders to the correct height and width with modeling compound (Fig. 12).

Any undercuts in the acrylic resin bases are removed and replaced with modeling compound to facilitate flask separation during processing (Figs. 13 and 14).

Following these preliminary procedures, if they are found to be necessary, the primary basing impression is made in a zinc oxide and eugenol impression paste. The mixed paste is applied to the impression surface of the bases and the partial denture is seated to position. The fingers are held against the rests on the terminal abutments and on all framework contacts anterior to the terminal retainers. The patient is not permitted to close the teeth into centric occlusion as unequal pressure on the ridges, framework rotation, or both may result. Any occlusal discrepancies

Fig. 13.

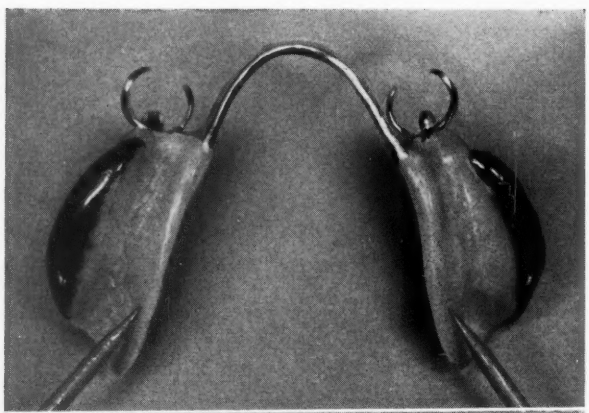

Fig. 14.

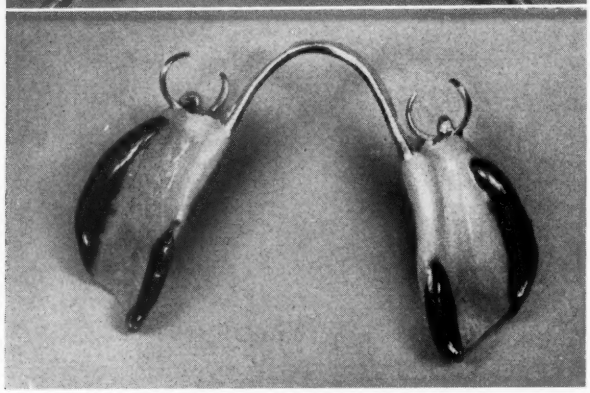

Fig. 13.—The pointers indicate where the lingual flange undercuts in the acrylic resin have been removed.

Fig. 14.—The undercuts in the lingual flanges are reproduced in modeling compound.

introduced by this step and by subsequent processing are corrected by intraoral grinding. After the impression paste has set, the partial denture is removed, the excess paste is trimmed away with a warmed sharp knife, and the corrected partial denture is reseated and tested for stability (Fig. 15). If the desired stability has not been attained, the procedure is repeated. A second layer of paste is added to the impression surface of the bases, and the denture is reseated in the same manner.

After setting, the partial denture is removed, the excess paste is trimmed, and a check is made for stability. Usually satisfactory stability will be attained following a second addition of impression paste. The partial denture is then flasked, processed, and polished. Upon insertion, premature or heavy occlusion will be found on the artificial teeth of the denture bases. However, the degree is such that it can readily be corrected by modest intraoral grinding.

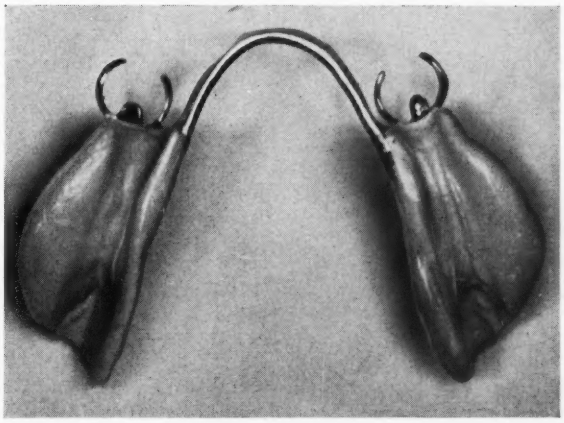

Fig. 15.—The completed basing impression (Group III).

GROUP IV. FREE-END DENTURE BASES WITH MODERATE RIDGE RESORPTION

When a moderate degree of ridge resorption is found under a free-end partial denture, the technique just described is not adequate. The zinc oxide and eugenol impression paste cannot take up the discrepancies that are present, and even repeated additions of layer to layer will not give a satisfactory result. A spacing supplement must be added to the rebasing procedure (Fig. 16). This consists of applying modeling compound to correct the discrepancies that exist between the bases and the resorbed ridges. The impression surfaces of the bases are prepared for the reception of the compound by grinding away these surfaces to provide a minimum of 2 mm. of space (Fig. 17). If the modeling compound is placed on the unprepared impression surfaces, it is in a thin layer, and proper, thorough heating is not possible. Such uneven and inadequate heating of the modeling compound causes undesirable and injurious soft tissue displacement.

A layer of modeling compound is then applied to the prepared impression surface of the base, either by a tracing stick or by a softened wafer (Fig. 18). The modeling compound is thoroughly softened after it is applied to the base by heating it with a pointed flame from an alcohol torch (Fig. 19) and tempered by placing it in hot water. The bases are left immersed in the hot water bath for at least 30 seconds to permit the heat to penetrate into the acrylic resin of the denture bases. This allows the modeling compound to remain soft and flow freely for a longer period of time, and thereby it minimizes tissue displacement. The partial denture is

seated, and care is taken to make sure that the framework is seated correctly. The fingers are held against the rests on the terminal abutments and on all contacts that may be present on teeth anterior to the terminal abutments. The partial denture is removed and the excess compound is trimmed away.

Fig. 16.

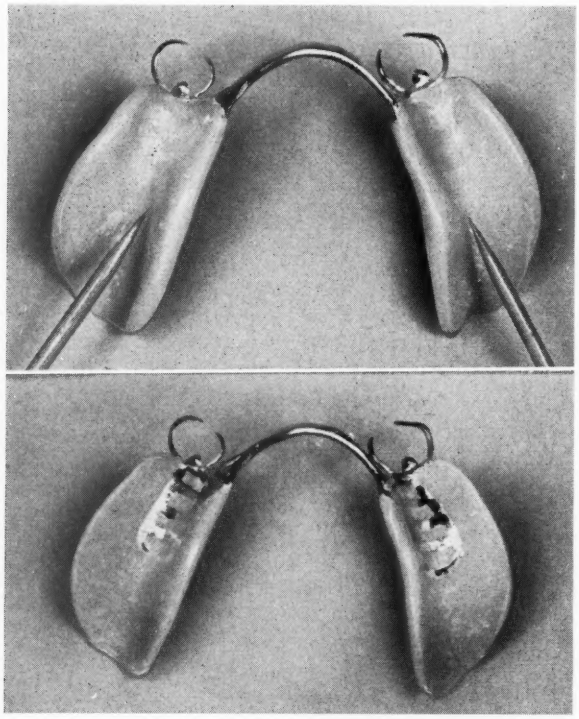

Fig. 17.

Fig. 16.—A free-end denture base partial denture requiring rebasing where marked ridge resorption has occurred (Group IV). The light pointers indicate the space between the impression surfaces of the bases and the ridges and the need for a spacing supplement.

Fig. 17.—Acrylic resin is ground away from impression surfaces of bases.

The border extensions are checked. In some places the modeling compound may have caused overextensions, and in other places underextension borders may be present. Overextensions are cut down, and underextended borders are built up with compound additions and reseating (Figs. 20 and 21). When the borders have been correctly formed, the rebasing procedure is completed by making a primary basing impression in the denture bases that now have had the spacing supplement added. The primary basing impression is made by placing a thin mix of zinc oxide and eugenol impression paste over the modeling compound on the impression surfaces of the bases. The partial denture is seated, and the fingers are placed against the rests on terminal abutments and on all contacts on teeth anterior to the terminal abutments. After the impression material is set, the partial denture is removed, and excess paste is trimmed away (Fig. 22). The denture is then reseated and

Fig. 18.

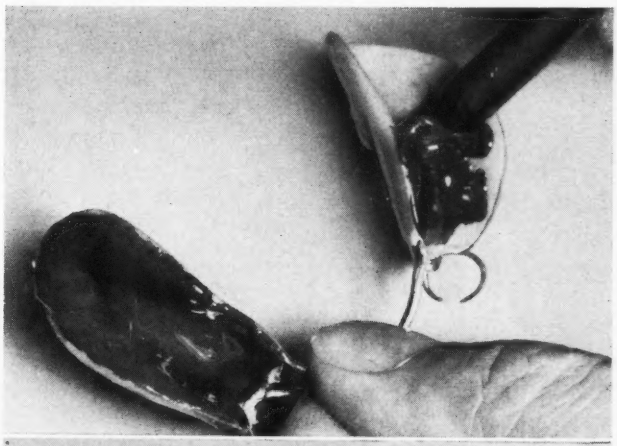

Fig. 19.

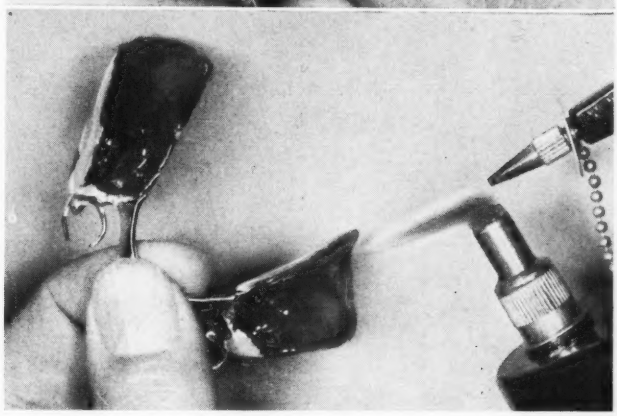

Fig. 18.—Modeling compound is applied to the prepared impression surfaces of the denture bases with a tracing stick.

Fig. 19.—The modeling compound is thoroughly heated.

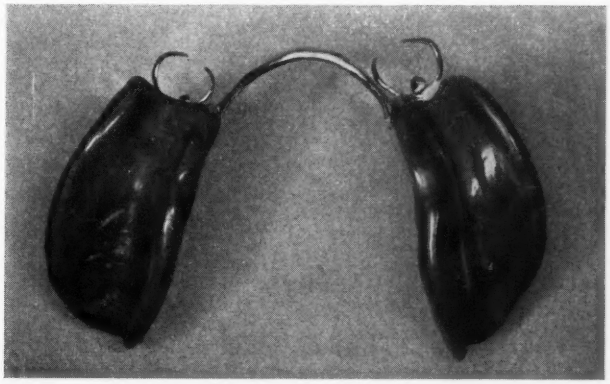

Fig. 20.—The completed spacing and border supplements.

tested for stability and occlusion. Stability should be good, and the occlusal contacts will be found to be premature. A careful study of the extent of occlusal discrepancies must be made. If it is judged that they can be corrected by a reasonable amount of grinding, no further steps are necessary, and flasking and processing can be accomplished. However, if the occlusal discrepancies are found to be so great that tooth mutilation will result from an attempt to make corrections by grinding, an occlusion supplement must be added to the procedure. This changes the classification of the partial denture and places it in Group V.

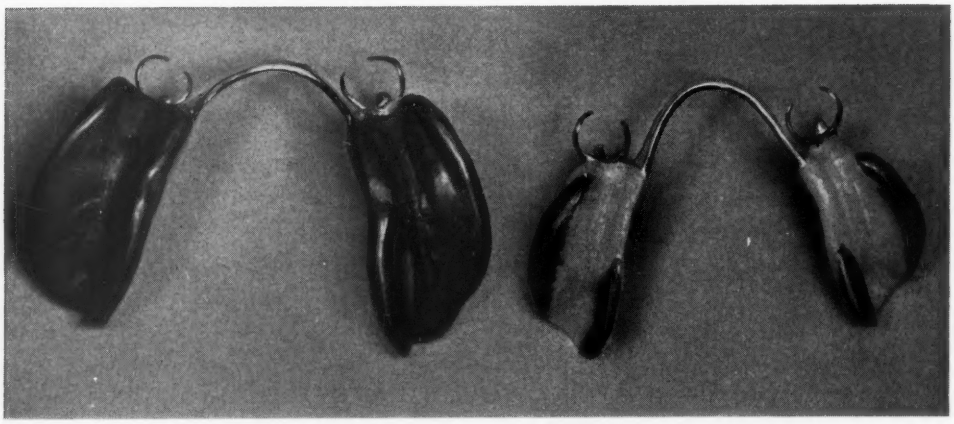

Fig. 21.—Comparison of partial dentures requiring rebasing. *Left,* A partial denture in Group IV. The presence of moderate ridge resorption requires a spacing supplement in addition to the border supplement before the final basing impression is made. *Right,* A partial denture in Group III. Because of slight ridge resorption, only a border supplement is required before the final basing impression is made.

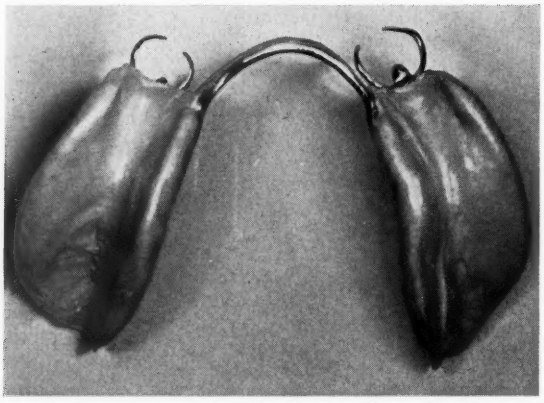

Fig. 22.—The completed basing impression (Group IV).

GROUP V. FREE-END DENTURE BASES WITH MARKED RIDGE RESORPTION

Marked ridge resorption under free-end partial denture bases induces two serious changes in the original relationship of the denture to its supporting struc-

tures. The first is a disturbance of the occlusal contacts, and the second is a rotation of the framework. Both must be properly corrected by a rebasing procedure. To do so, a framework supplement and an occlusion supplement must be added to the primary basing procedure with its spacing and border supplements that are used in situations where ridge resorption is less pronounced (Fig. 23).

Fig. 23.

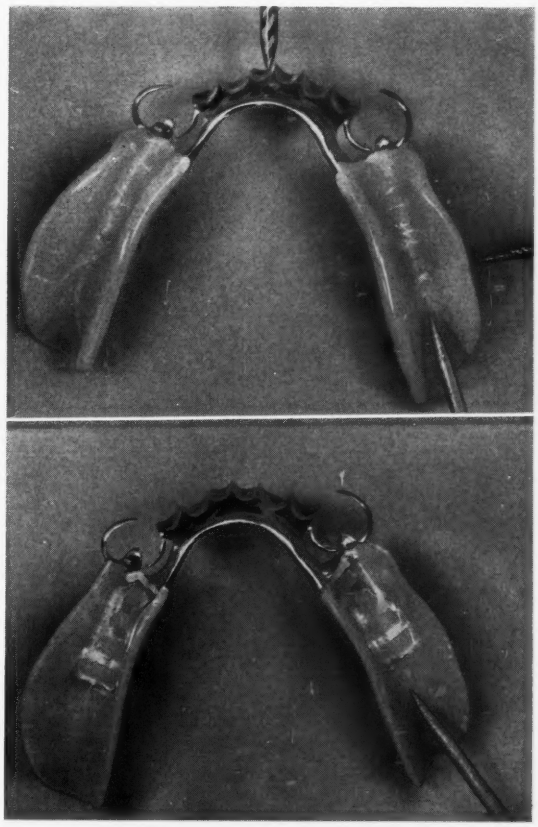

Fig. 24.

Fig. 23.—A free-end base partial denture requiring rebasing where marked ridge resorption and framework rotation have occurred (Group V). The dark pointer indicates border underextension and the need of a border supplement. The light pointer indicates the space between the impression surface of the base and ridges, thereby requiring a spacing supplement. The striped pointer indicates the presence of framework rotation and the need for a framework supplement.

Fig. 24.—The acrylic resin material is ground away from the impression surfaces of the bases.

The partial denture is prepared for a spacing supplement by grinding away the impression surfaces of the bases to a depth of 2 mm. or more if possible (Fig. 24). Stick or wafer modeling compound is applied liberally to the prepared impression surfaces. The modeling compound is thoroughly heated with a pointed alcohol flame, tempered by immersion in hot water for 30 seconds, and then seated in the mouth. In seating, the framework is carefully rotated back to its original relation-

ship to the natural teeth. The fingers are firmly placed on the terminal rests and on as many contacts anterior to the rests as is possible. After 30 seconds the denture is removed, and the modeling compound is thoroughly chilled in ice water (Fig. 25). The denture is returned to the mouth and tested for framework repositioning and denture base stability. Usually the framework repositioning is cor-

Fig. 25.

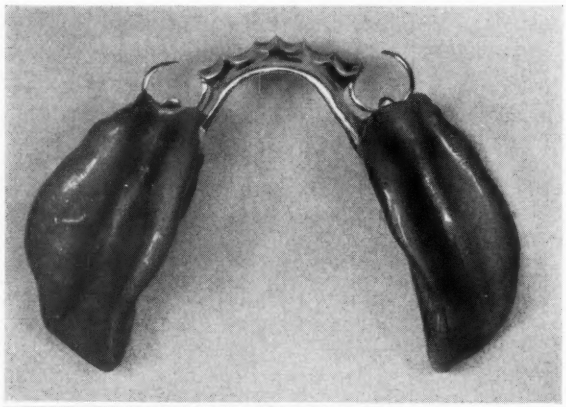

Fig. 26.

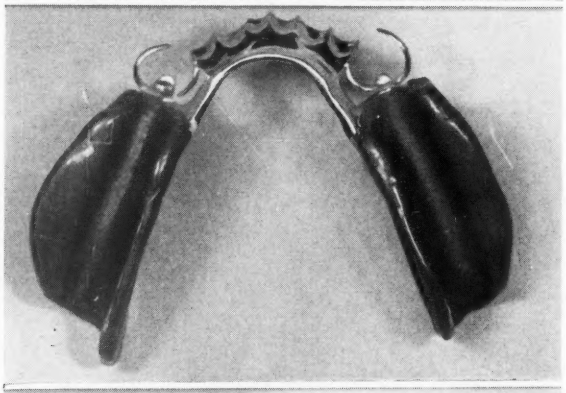

Fig. 27.

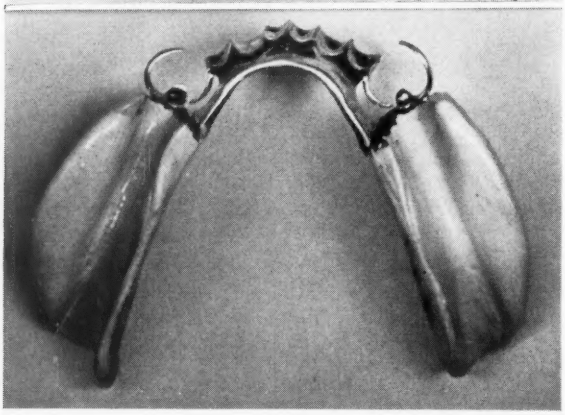

Fig. 25.—The denture after the addition of modeling compound and seating in mouth to correct framework rotation and the space between denture bases and ridges.

Fig. 26.—The partial denture with the completed spacing and border supplements.

Fig. 27.—The completed basing impression (Group V).

rect, but the denture bases do not have the desired degree of stability. Additional modeling compound is then applied to only the posterior two-thirds of the denture bases. The added modeling compound is warmed, tempered, and the partial denture is reseated. Again, extreme care must be taken to maintain correctly the contact of

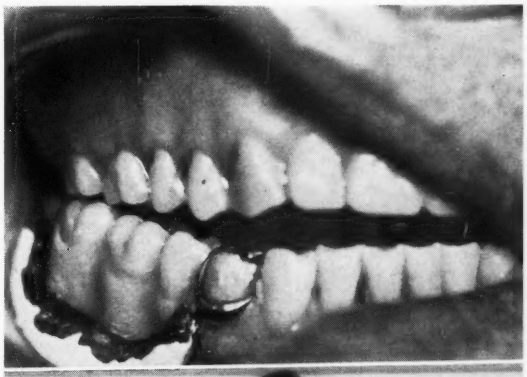

Fig. 28.

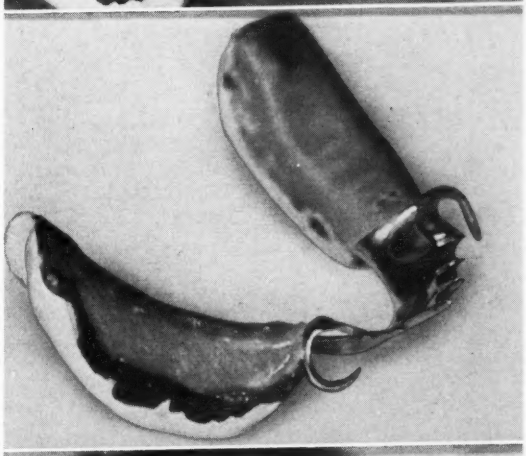

Fig. 29.

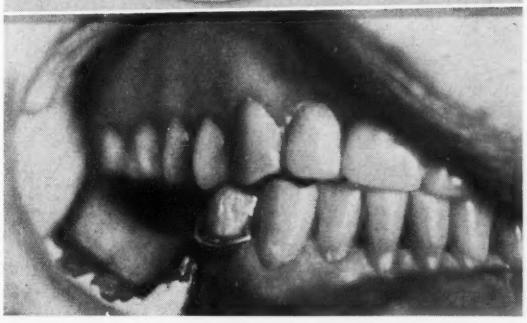

Fig. 30.

**Fig. 28.—Premature occlusion caused by the repositioning of the framework and the addition of modeling compound (the spacing supplement).**

**Fig. 29.—The teeth have been *ground* away, a maximum of acrylic resin base material has been removed, and the excess modeling compound and impression paste have been trimmed away from the posterior limits of the bases.**

**Fig. 30.—The trimmed bases are returned to the mouth and checked for adequate clearance from the opposing occlusion.**

the framework against natural teeth. The denture is removed, the modeling compound is chilled, and the stability of the bases is tested. Usually, denture base stability will be satisfactory at this point in the procedure. However, if denture base stability is still found to be inadequate, another addition of modeling compound is required. If so, modeling compound is applied only to the posterior half of the

Fig. 31.

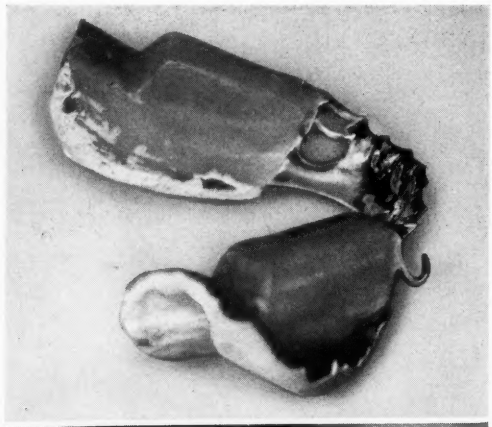

Fig. 32.

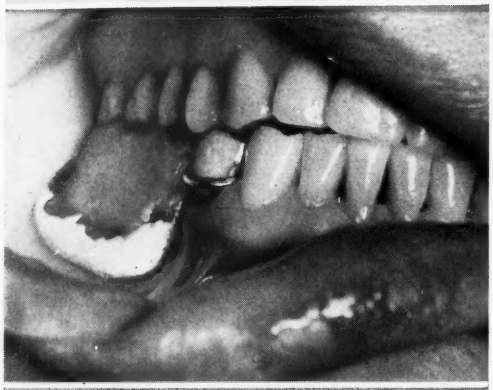

Fig. 33.

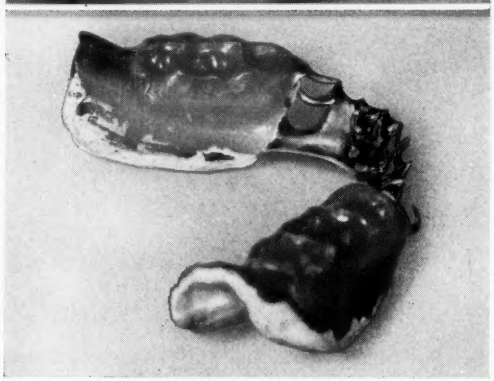

Fig. 31.—Occlusion rims are built on the trimmed denture bases.
Fig. 32.—The patient is closing in centric relation on softened occlusion rims.
Fig. 33.—The centric relation record on the occlusion rims.

denture bases and the steps of heating, tempering, chilling, and testing are repeated. With the attainment of denture base stability in addition to framework repositioning, the spacing and framework supplements of the rebasing procedure have been completed.

The border supplements must then be corrected. The border extensions of the corrected bases are observed. Where excess modeling compound has caused over-

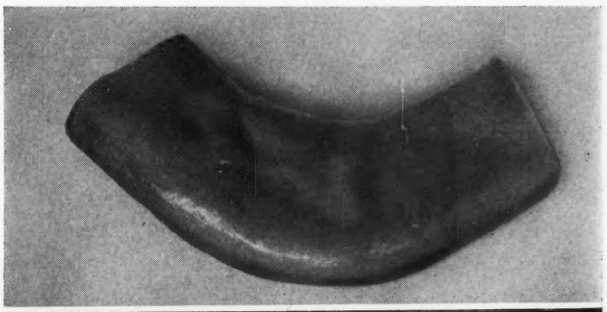

Fig. 34.

Fig. 35.

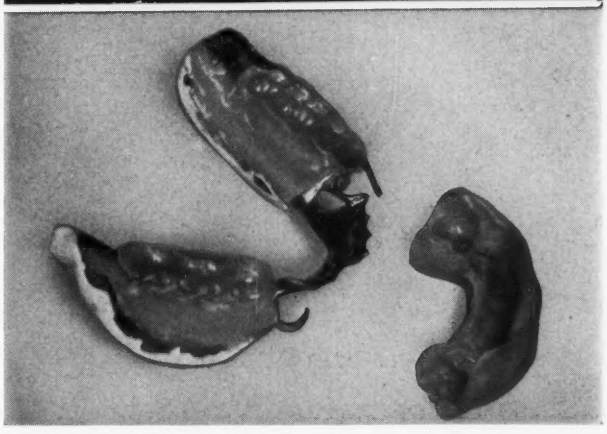

Fig. 36.

**Fig. 34.—Four layers of baseplate wax shaped for making an interocclusal record-impression of the natural teeth anterior to the denture bases.**

**Fig. 35.—The wax interocclusal record-impression of the natural teeth anterior to the denture bases and of the opposing teeth.**

**Fig. 36.—The completed wax interocclusal record-impression and centric relation record on the occlusion rims.**

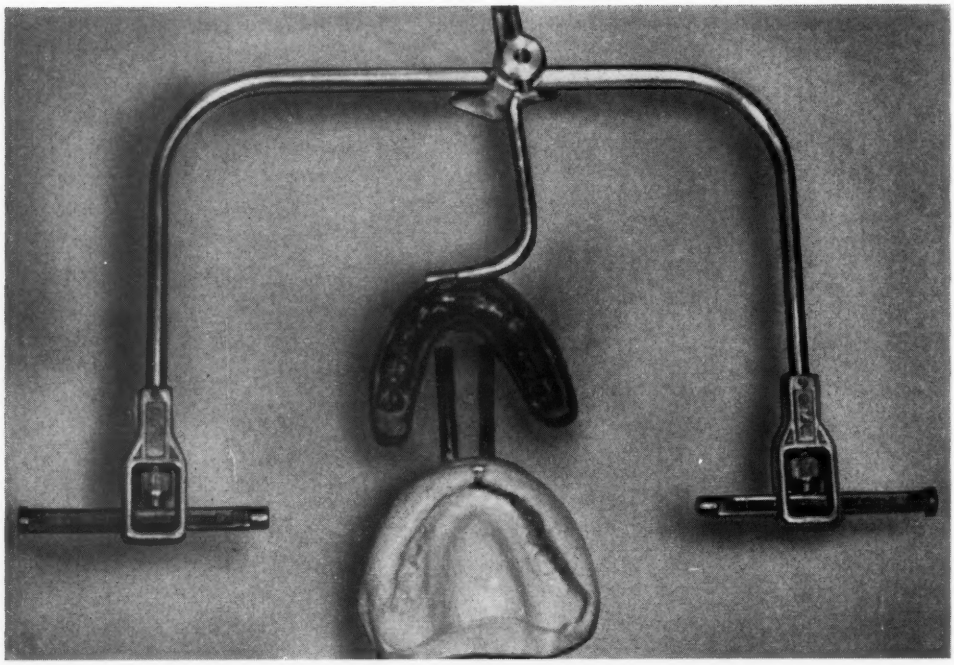

Fig. 37.—An alginate impression of the opposing teeth and jaw and the face-bow record.

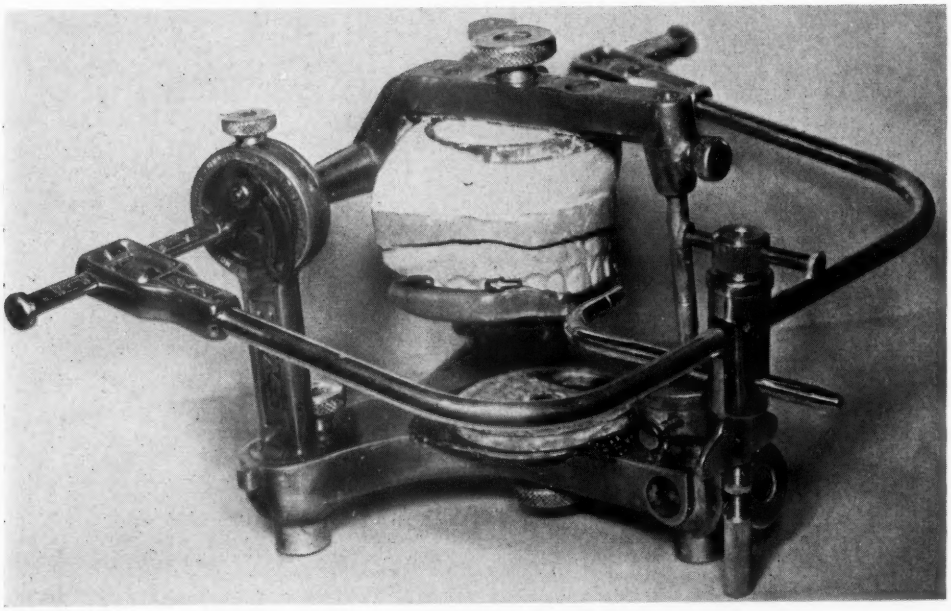

Fig. 38.—The upper cast is mounted according to the face-bow record.

extensions, the borders are trimmed down. If underextended borders are observed, modeling compound is added, and the denture is reseated until the borders are correct (Fig. 26).

Fig. 39.

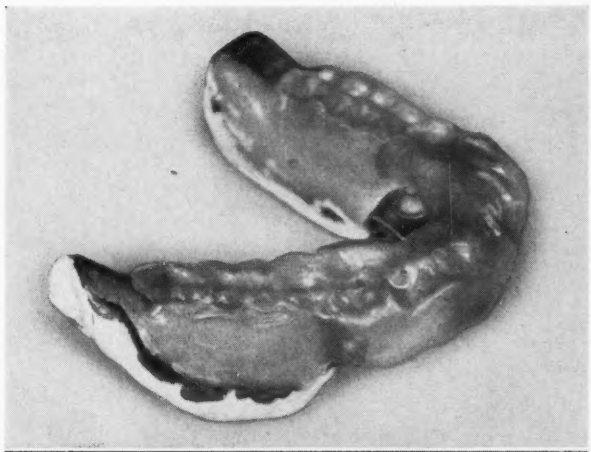

Fig. 40.

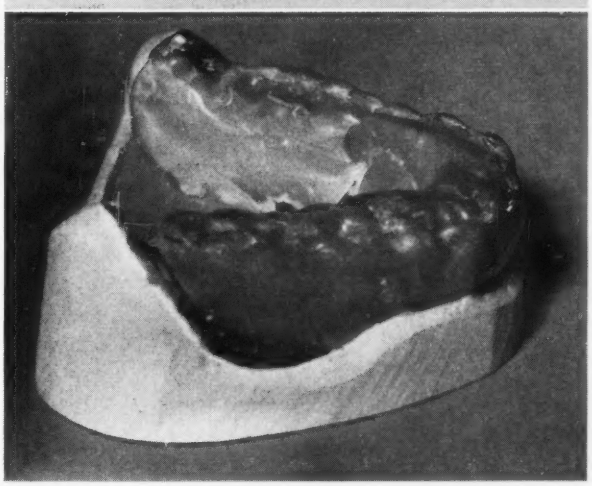

**Fig. 39.—The interocclusal record-impression is waxed to the rebased partial denture.**
**Fig. 40.—Cast poured.**

The primary basing impression is then made in the same manner as for the preceding groups. A thin mix of zinc oxide and eugenol impression paste is placed on the impression surfaces of the corrected denture bases. The partial denture is seated, and the repositioning of the framework is maintained by firm finger pressure until the impression paste has set. The excess is trimmed away with a warmed sharp knife (Fig. 27), and the partial denture is returned to the mouth. Because of the repositioning of the framework and the spacing supplement, the occlusion will be excessively premature (Fig. 28). An attempt to correct it by grinding after the rebased partial denture is processed will be unsatisfactory and would result in

mutilation of the artificial teeth. Therefore, it is necessary to incorporate an occlusion supplement in the rebasing technique.

The artificial teeth are completely ground away with a heatless stone. Also, as much denture base material is removed as space permits. Excess modeling com-

Fig. 41.

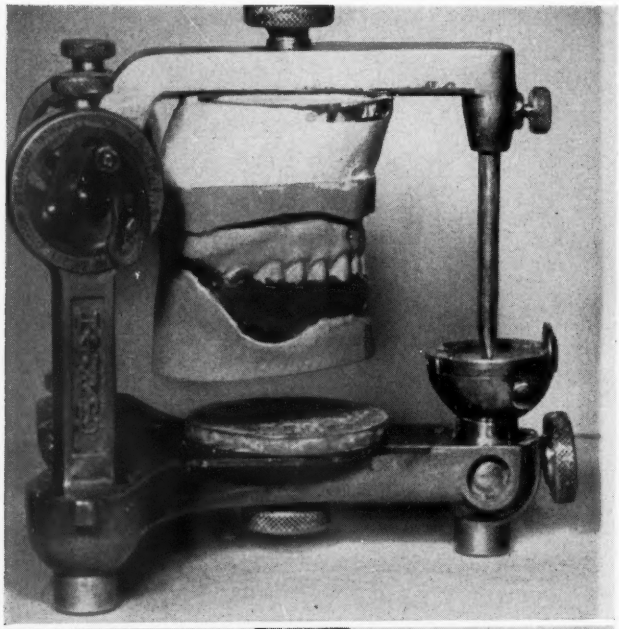

Fig. 42.

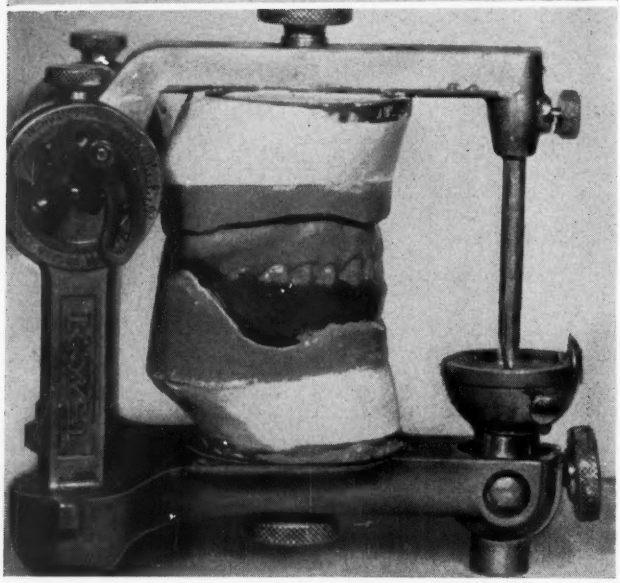

**Fig. 41.—The casts are sealed together according to the centric relation record.**
**Fig. 42.—The lower cast is mounted on the articulator.**

pound and impression paste are trimmed away from the area of the bases posterior to the artificial teeth (Fig. 29). The denture is returned to the mouth, and a check is made to determine that adequate clearance is present when the patient closes the mandible in centric position (Fig. 30).

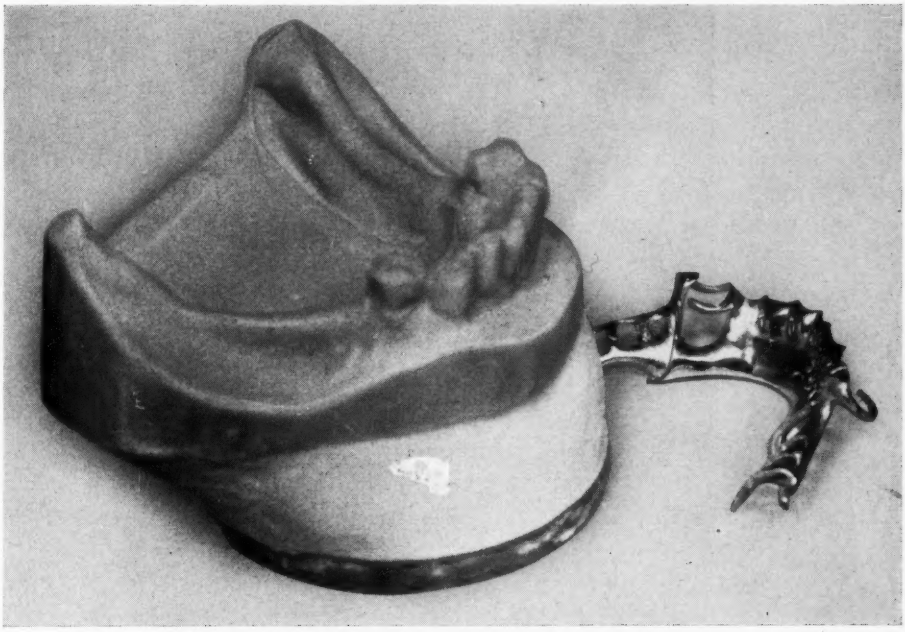

**Fig. 43.—The cast is separated and the old acrylic resin bases are stripped from the metal framework.**

Occlusion rims of pink baseplate wax are formed on the bases where the artificial teeth were ground away (Fig. 31). The occlusion rims are softened, the denture is seated, and the patient is guided to close the jaw in centric relation (Fig. 32). The denture is removed, the wax is chilled, the guide planes are cut away, and the record is rechecked in the mouth for accuracy (Fig. 33). A ⅜ inch wide strip is formed of four layers of baseplate wax and shaped in the form of a horseshoe (Fig. 34). Its length is trimmed to cover only the teeth anterior to the free-end bases of the partial denture. The strip of wax is thoroughly softened and placed over the teeth anterior to the free-end denture bases. The patient is guided to close the jaw into the centric relation previously recorded by the posterior occlusion rims. The wax is molded over the labial and buccal surface of the remaining teeth with the fingers, and the patient is instructed to mold the wax over the lingual surfaces of the teeth with the tongue (Fig. 35). The wax is chilled and then removed (Fig. 36). The purpose of this wax interocclusal record-impression is to provide an approximate model of the remaining natural teeth that will be helpful in setting up new artificial teeth.

An impression of the opposing dental arch is made in an alginate impression material and, where indicated, a face-bow record is made (Fig. 37). Stone is

Fig. 44.

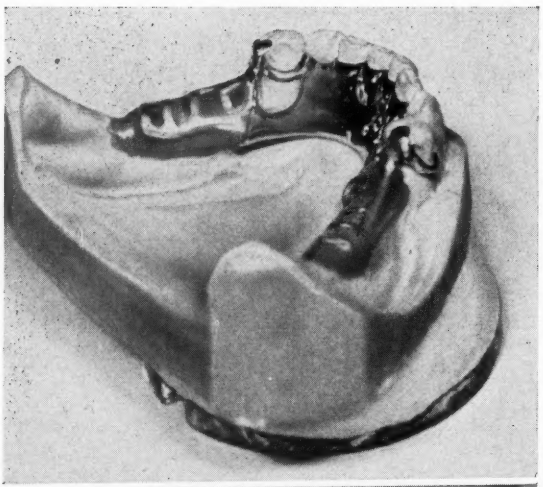

Fig. 45.

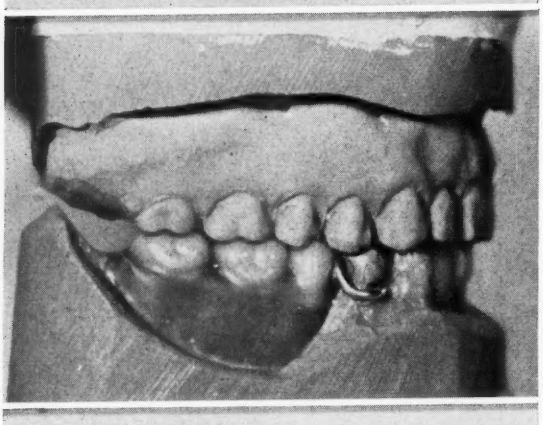

Fig. 46.

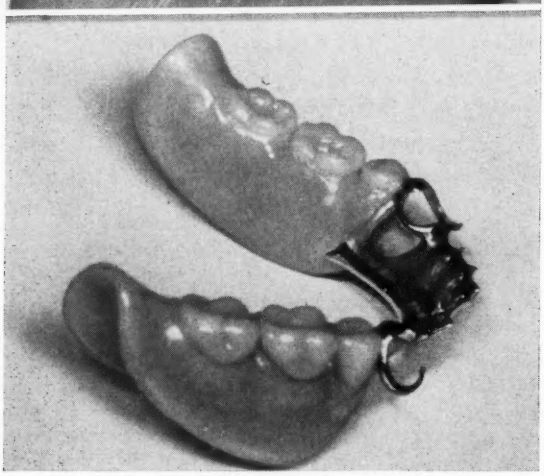

Fig. 44.—The metal framework is waxed to the cast.
Fig. 45.—New artificial posterior teeth are set into occlusion.
Fig. 46.—The rebased and processed denture.

poured into the alginate impression, and the cast is separated and mounted on an adjustable articulator according to the face-bow record (Fig. 38).

The interocclusal record-impression is firmly waxed to the rebased partial denture, and a stone cast is poured into both (Figs. 39 and 40). After setting, the cast is not separated but it is set against the articulated cast of the opposing jaw according to the centric relation record. The casts are sealed together with sticky wax, and the free cast is mounted on the articulator (Figs. 41 and 42).

The rebased partial denture is separated from the cast and the old acrylic resin denture bases are stripped from the metal framework (Fig. 43). The framework is securely waxed to the ridges of the stone cast, and new artificial posterior teeth are set up for optimum occlusion (Figs. 44 and 45). The wax-up of the bases is completed, and the denture is flasked and processed. After processing, the partial denture is inserted and the occlusion equilibrated either intraorally, if natural opposing teeth are present, or by an interocclusal record remount technique, if an extensive partial denture or a complete denture is present (Figs. 46 and 47).

Fig. 47.—The occlusion of the denture rebased and including an occlusion supplement.

GROUP VI. FREE-END DENTURE BASES WITH EXCESSIVE RIDGE RESORPTION

When excessive ridge resorption has occurred under a free-end partial denture, none of the previously described techniques will be adequate. Marked framework rotation is usually present, and the denture bases have no stability and seat that may be used as a starting point for rebasing. If the natural teeth have drifted because of torque-producing stresses, no part of the partial denture can be salvaged, and an entirely new construction is required. However, if no noticeable tooth movement has occurred, the existing framework can be utilized for the assembly of a new partial denture. The procedure is essentially the same as that used for basic partial denture construction, except that no new framework is fabricated.

An impression of the mouth is made by whatever material and technique the dentist prefers for free-end denture base partial dentures. After a cast is poured,

the acrylic resin bases and the teeth are stripped from the metal framework. The framework is fitted to the stone cast. If some binding is encountered, the interfering points are scraped away on the teeth of the cast. A satisfactory seating of the metal framework must be accomplished, or otherwise the reassembled partial denture will be unsatisfactory. After the framework is properly seated, basetrays and occlusion rims are attached to the metal framework for making jaw relation records. The same steps are followed as for the construction and insertion of a new partial denture.

### GROUP VII. COMBINATION TOOTH-BOUNDED AND FREE-END DENTURE BASES

In many instances, partial dentures have a combination of tooth-bounded and free-end denture bases. If rebasing is required, each base is analyzed independently and its requirements determined. The bases are then classified in their proper group, and the procedures are selected accordingly. If the required procedures are closely similar, both bases may be handled simultaneously. However, if a big difference in the required procedures exists, the base requiring the simpler technique is corrected first, and then the base requiring the more complex technique is corrected. Clinically, a great number of combination techniques are possible; however, they can be automatically formulated by referring to and following the basic classification.

The problems in rebasing partial dentures have many facets and ramifications. The almost countless variations of tooth positions and states of remaining natural teeth and residual ridges contribute to the diverse conditions in each mouth and to the varying degrees of structural changes that occur after the insertion and wearing of a partial denture. The recognition of these changes and the institution of remedial procedures are necessary to preserve the structures of a partially edentulous mouth. The grouping and the associated technical procedures presented constitute an attempt to accomplish this objective and to take the rebasing of a removable partial denture out of the category of a hit-and-miss procedure.

### SUMMARY

Partial dentures cannot be successfully rebased by a routine standardized technique. Critical clinical factors determine the procedure followed. These factors are: (1) the type of denture bases present on the partial denture, (2) the degree of ridge resorption under the denture bases, (3) the accuracy of the border extension of the denture bases, (4) the occlusion of the artificial teeth on the denture bases, and (5) the presence of framework rotation.

A consideration of these factors dictates the classification of partial dentures requiring rebasing into seven definite groups requiring supplements to a general basic technique. The supplements that are added to the basic technique according to

changes observed are: (1) the border supplement, (2) the spacing supplement, (3) the framework supplement, and (4) the occlusion supplement.

The problems encountered in each group of the classification are analyzed, and procedures incorporating the various required supplements are described.

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## *FIXED PARTIAL DENTURES*

# THEORY OF CENTRIC CORRECTION IN NATURAL TEETH

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A METHOD OF OCCLUSAL ADJUSTMENT was presented in a previous article.[1] Considerations in this article will continue to be confined, for reasons of simplicity, to the accepted normal occlusion or the conventionally accepted centric occlusion as presented by normal, natural tooth arrangement.[2] The explanation of the basic, theoretic concept of this approach was inadequately stated earlier because of (1) a lack of a standardized nomenclature, and (2) a lack of even "unstandardized" terms with which to clearly express the concept. A group effort by the Academy of Denture Prosthetics[3] has eliminated the former of these reasons for ambiguity. However, the terminology suggested in the resulting glossary is still one which expresses relationships *primarily* in concepts of *complete denture prosthesis* and, therefore, still does not eliminate the latter inadequacy.

In complete denture prosthesis, occlusal harmony is accomplished by grinding and milling of teeth whose positions have been controlled by the dentist. Such similar approaches in a natural dentition are possible only when the entire occlusion is being restored.[4] When facing the problem of creating a relatively stable occlusal harmony in the natural teeth without the opportunity of so positively altering the occlusion, then different factors must be considered. In considering this problem, when only negative or subtractive changes in the natural teeth are to be employed, new terms appear to be of necessity. There are certain basic jaw-to-jaw and tooth-to-tooth relationships, peculiar to this latter approach that must be designated. This is necessary for an understanding of this basic theoretic concept. The relationships for which no terms exist are to be described; a term for each will be suggested, and the concept will be restated with their use.

### TERMS

The Academy of Denture Prosthetics has defined centric relation as a jaw-to-jaw or joint-to-skull relationship in its *Glossary of Prosthodontic Terms*[3]: *"Centric relation:* The most retruded relation of the mandible to the maxillae when the

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condyles are in the most posterior unstrained position in the glenoid fossae from which lateral movement can be made, at any given degree of jaw separation."

It defines centric occlusion as a tooth-to-tooth relationship: *"Centric occlusion:* The relation of opposing occlusal surfaces which provides the maximum planned contact and/or intercuspation."[3]

These terms and definitions are accepted and used in the following discussion. However, there are other specific relations which have not had adequate names or definitions.

Fig. 1 is a schematic illustration of a patient before treatment. The teeth are in their original centric occlusion ($O_1$, $I_1$) in the upper drawing. However, the condyles (and menisci) are not in centric relation ($C_1$). There is *no term* for the unstrained positional relationship of joint-to-skull in this position when the natural teeth are in their centric occlusion. $VD_1$ is a measurement of the vertical dimension of occlusion.

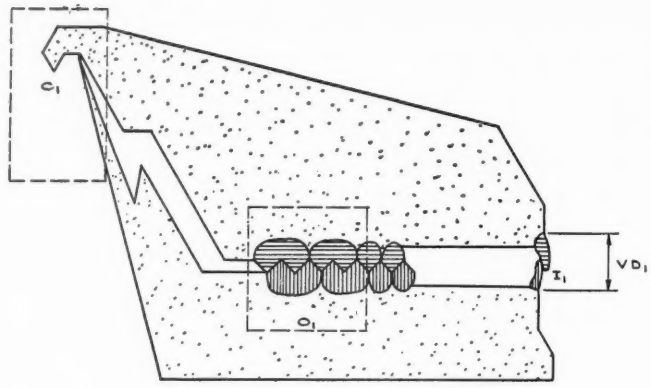
In the lower drawing (Fig. 1), the condyles and menisci are in centric relation ($C_2$). However, the teeth ($O_2$, $I_2$) are not in "the relation . . . which provides the maximum planned contact and/or intercuspation."[3] There is *no term* for the positional relationship of teeth-to-teeth when the jaws are in the centric relation. Note that $VD_2$ is greater than $VD_1$; the vertical dimension of occlusion is increased in this position.

Terms for the following positional relationships still are lacking when the negative changing of a natural dentition is considered:

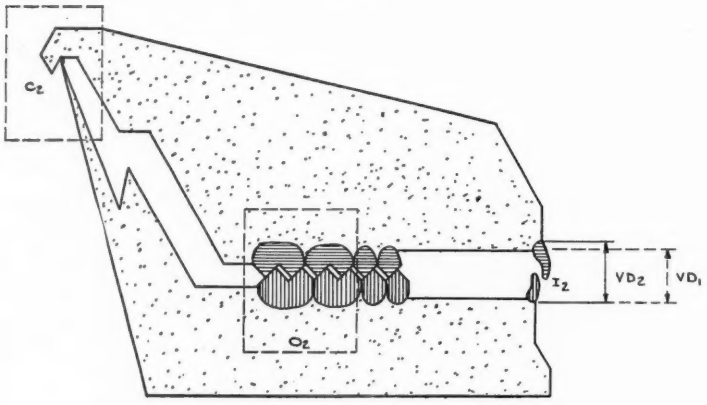
(1) The unstrained jaw-to-jaw, or joint-to-skull relationship existing when the patient's teeth are in their original, uncorrected centric occlusion. The term *"procentric relation"* is suggested for this unstrained jaw-to-jaw relationship and will be used in this discussion. (Note that, in the great majority of patients, this is an *eccentric jaw-to-jaw relation by definition.)*

(2) The tooth-to-tooth relationship existing in the posterior teeth, when the joint and skull are in centric relation. The term *"retrocentric occlusion"* is suggested and will be used in this discussion. (Note that, in the great majority of patients, this is an *eccentric tooth-to-tooth occlusion by definition.)* It is obvious that no incisor or canine contact can be present in this occlusion either before or after occlusal correction by negative or subtractive changes alone.

It becomes extremely difficult to state the crux of this theoretic concept without combining terms in such a fashion that, with one word, the combined positions of *both* jaw-to-jaw (or joint-to-skull) *and* tooth-to-tooth are denoted. In complete denture construction, it has proved to be sound clinical procedure to arrange artificial teeth in occlusal harmony by having ". . . centric occlusion . . . coincide with centric jaw relation . . . ."[3, 5] However, rarely, if ever, is a negative or subtractive change in the occlusal surfaces of *natural* teeth possible, such that centric relation of jaws and centric occlusion of teeth will ". . . coincide . . . ."[3, 5] Therefore, there are *two* positions that must be dealt with in this concept of natural dentition centric correction by grinding; two positions that can *never* (or very rarely) be considered other than as two separate entities in the patient with natural teeth. These two positions are: (a) *"median contact position,"* the teeth in *centric occlusion* with




MEDIAN CONTACT POSITION
before treatment




RETRUDED CONTACT POSITION
before treatment

Fig. 1.—*Above,* Median contact position before treatment. *($C_1$),* The condyle is slightly forward in the glenoid fossa, therefore, the mandible is in an eccentric position. *($O_1$),* The teeth are in centric occlusion; $I_1$, indicates the incisor relation in this occlusion. *($VD_1$),* The vertical dimension of occlusion in this position. *Below,* Retruded contact position before treatment. *($C_2$),* The condyle is in centric relation, therefore, the mandible is attempting to assume centric position but the occlusion prevents it from doing so. *($O_2$),* The teeth are in an incorrect retrocentric occlusion, therefore, they are in an intolerable eccentric occlusion; $I_2$ indicates the incisor relation in this position. *($VD_2$),* The increased vertical dimension of occlusion in this position, which is forced by the incline planes on the posterior teeth. $VD_2$ will equal $VD_1$ when the occlusion is properly modified as in Fig. 2 and Fig. 3, q.v.

the jaws in *"procentric relation"** and (b) *"retruded contact position,"* the teeth in *"retrocentric occlusion"** with the jaws in *"centric relation."* For reference purposes, *"median contact position"* has been called *"centric position,"* previously,

*The alternate terms, *anterocentric relation* and *posterocentric occlusion* seem to possess a more purely spacial-relationship connotation. However, the suggestion of *protrusion* in the instance of the joints in "procentric relation" and the suggestion of *retrusion* in the instance of the teeth in "retrocentric occlusion" demanded the selection of the terms as they appear.

and *"retruded contact position"* has been called *"retrocentric position,"* both original and corrected.[1]

## THE BASIC THEORETIC CONCEPT

It is desirable to achieve relative stability as the result of an occlusal correction by grinding. If major subtractive changes in the once-altered, natural occlusal surfaces are found later to be necessary for periodontal reasons, these later findings are indicative of improper approaches in the original corrective procedures.

The goal in a proper occlusal correction by subtractive grinding alone is to arrange for the several components of the masticating mechanism to function with none of them being denied their full range of physiologic freedom in function and none of them being forced beyond their physiologic limits during the masticating process. These components of the chewing mechanism are: (1) the temporomandibular joints, (2) the neuromuscular system of mastication, and (3) the teeth and periodontium.

I theorize that in the great majority of human skulls there exists in each temporal (glenoid) fossa a small "section-of-a-sphere" for functional articulation of the condyle and meniscus between its "procentric relation position" and its "centric relation position." Theoretically, each patient's condyles and menisci traverse these "sections-of-spheres" in innumerable combinations of movements during function. There is wide dimensional variation anteroposteriorly in these "sections-of-spheres"; this variation exists between joints from patient to patient and even from one joint to the other in the same patient. There is also a similarly diverse variation in their curvatures so that, in some joints, the condylar path from its "procentric relation position" to its "centric relation position," and vice versa, is in some slight angulation with the sagittal plane. Suitable accommodating approaches must be made for each anatomically varying set of circumstances during each individual correction.

I further theorize that during heavy function the optimum, balanced equilibrium of maximal, masticatory-muscular contraction occurs as the mandible passes through median contact position (Fig. 1). However, very powerful muscular contractions occur as the mandible makes its myriads of combinations of movements between median contact position and retruded contact position (Fig. 1) during function. The anatomy of the joints theoretically accommodates these innumerable combinations of movements, and the reflex neuromusculature system moves the mandible into them. These latter forces, namely those resulting from very powerful muscular contractions *behind* median contact position, are potentially damaging if the teeth receive them on inclined planes. They are potentially damaging, either to the joints themselves or to the periodontium, since the inclined planes *force* either a forward and/or lateral physiologically intolerable shift to the mandible.

The theory then calls for an alteration in the fossae (or occlusal areas opposing bearing cusps) in the teeth. These alterations must be made such that harmoniously complementary "sections-of-spheres" are produced in them for cusp travel. These "sections-of-spheres" in the fossae theoretically are such that the mandible can assume any combination of movements between median contact position and retruded contact position with no change in the occlusal vertical dimen-

sion. Thus, the inclined planes are removed, and only axial forces are delivered through the teeth during these movements.

After a theoretically proper occlusal adjustment, when the condyles and menisci are bilaterally seated at the *posterior* borders of their small "sections-of-spheres" (in centric relation), the *posterior* teeth are in their then-corrected retrocentric occlusion. The posterior occlusal vertical dimension is the same as that of the original centric occlusion, and only axial forces are being delivered through the teeth to the periodontium. Retruded contact position is then physiologically correct (Fig. 2).

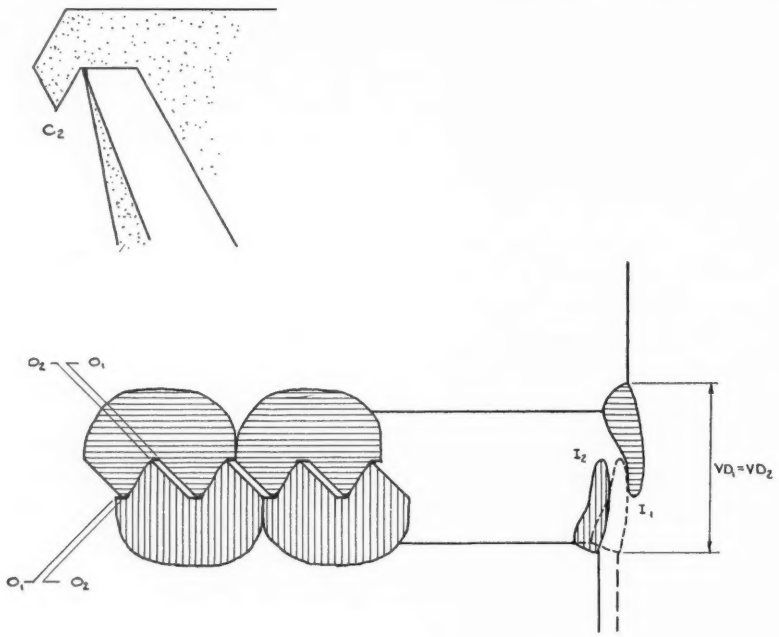



Fig. 2.—The corrected retruded contact position when the joint is in the position of centric relation $C_2$. Retrocentric occlusion has been altered by changing the fossae or occlusal surfaces of teeth receiving bearing cusps ($O_2$, $O_1$) on the maxilla and ($O_1$, $O_2$) on the mandible. Now the retruded contact position can be achieved at the same vertical dimension as that of median contact position, and the mandible can achieve centric position. $VD_2$ now equals $VD_1$ as measured at the incisors. The incisors are not in function ($I_2$); the dotted incisor indicates its median contact position. The inclined planes no longer contact prematurely in the retrocentric occlusion of the posterior teeth.

When the condyles and menisci are bilaterally seated at the *anterior* borders of their small "sections-of-spheres" (in their procentric relation), *all* of the teeth are still in their original centric occlusion (Fig. 3). Median contact position is physiologically correct *only if all of the teeth are still in their original centric occlusion.* In no sense can the mandible be said to be in "forward protrusion" *if the subtractive changing of natural teeth is the basis of consideration* when it assumes median contact position.

Clinical observation has shown that, in order to achieve a satisfactory degree of stability in the result of an occlusal adjustment by grinding the natural teeth, there is *one* combined jaw-to-jaw and tooth-to-tooth positional relationship, herein described as median contact position, that is of paramount importance. This position must be treated as an inviolate stop for the occlusion and must *never* (or only in extremely rare instances) be disturbed. At least point-to-plane or, better, point-to-section-of-a-sphere contacts must be left unstoned on every tooth-to-tooth relationship in this median contact position, or dire tooth movement with resultant collapse of the occlusion will occur.

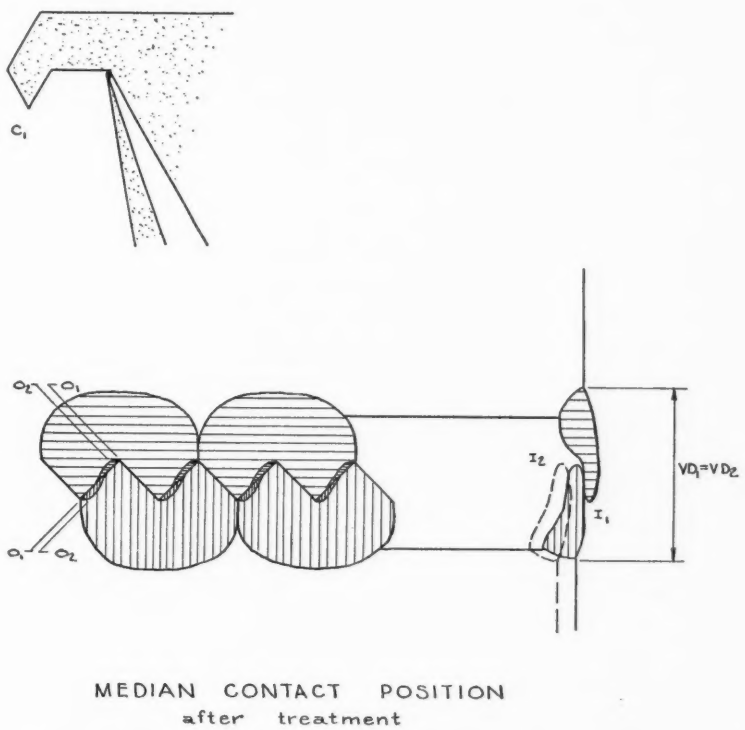



Fig. 3.—Corrected median contact position. The joints are in procentric relation *($C_1$)*. The centric occlusion has been preserved, i.e., points-to-sections-of-a-sphere contacts, or stops, in the original centric occlusion still remain on *all* teeth *($O_1$)*. The incisors are in their original centric occlusion *($I_1$)*; the dotted incisor *($I_2$)* indicates its retruded contact position. The shaded areas indicate, very schematically, where tooth structure was removed during the correction. A three-dimensional concept must be visualized. The teeth nowise appear like these drawings after a proper occlusal adjustment by grinding.

In complete denture prosthesis and in complete occlusal restoration,[4] retruded contact position *must be* considered the point of reference, and arrangements are made *to accommodate* the median contact position. However, this procedure *must be reversed* when occlusal correction of a natural dentition is done by grinding. Then the median contact position *must be* considered the point of reference, and arrangements *to accommodate* the retruded contact position must be made.

It is the task of the dentist attempting the occlusal adjustment to create in the fossae in the natural teeth harmonious sections-of-spheres to allow for cusp-travel during free mandibular movement from the median contact position to the retruded contact position and vice versa *with no change in vertical dimension from one position to the other.* At the same time, at least points-to-sections-of-a-sphere contacts must be maintained in *all* teeth in median contact position; and these same points-to-sections-of-a-sphere contacts must be employed in *all the posterior teeth* throughout this then-free mandibular movement (Figs. 2 and 3). It is obvious that anterior (incisor and canine) contact is lost as soon as the jaw moves even the slightest distance from the median contact position toward the retruded contact position.

The techniques for these occlusal adjustments, as well as those for the lateral and protrusive corrections, have been stated previously.[1] Only this point needs stressing: median contact position is treated as the point of reference, and the tooth-to-tooth contact (in original centric occlusion) in this position is always considered inviolate.

SUMMARY

A theoretic concept of centric occlusal correction in natural teeth by stoning or grinding them is made in light of recent nomenclature standardization. Suggestions for two additional terms, one for jaw-to-jaw relation, called "procentric relation," and one for tooth-to-tooth relation, called "retrocentric occlusion," are made.

A plea is made for treating the combined jaw-to-jaw and tooth-to-tooth positional relationship called the median contact position as a point of reference in the occlusal adjustment of natural teeth. This is a position of the jaws in procentric relation and the teeth in centric occlusion and is an inviolate position in stoning for occlusal corrections. The dentist is admonished to preserve at least point-to-"sections-of-a-sphere" contacts between all opposing natural teeth during the occlusal adjustment in this combined jaw-to-jaw and tooth-to-tooth relationship.

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# ACCURATE CASTS AND POSITIONAL RELATION RECORDS

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MOST DENTISTS PROBABLY WOULD agree that the use of wax interocclusal records for recording maxillomandibular positional relations and for adjusting the articulator is frequently a source of error. The objective of the method to be described is the elimination of this source of error. This method has been found useful clinically and may be worthy of the consideration of the dentist who finds wax interocclusal records less than satisfactory.

The method is derived in part from the technique used in connection with gnathologic instruments. Maxillary and mandibular clutches are constructed, to the front of which are attached detachable studs. These studs in turn carry the tracing devices.

Acrylic resin clutches held in place with a thiokol-type (rubber base) impression material are used instead of sectional aluminum clutches cemented onto the teeth with zinc oxide and eugenol cement (gnathologic technique). The thiokol impression material produces a sufficiently rigid attachment of the clutches to the dental arches, and at the same time it produces an accurate impression and makes the removal of the clutch quite easy.

## PRELIMINARY MOUNTINGS

Preliminary casts are mounted as accurately as possible in an adjustable articulator by means of a face-bow. The condylar guidances on the articulator are adjusted by means of a wax protrusive interocclusal record.

## CLUTCH CONSTRUCTION AND IMPRESSIONS

The acrylic resin clutches are constructed on the casts. The occlusal, buccal, labial, and lingual surfaces of the dental arches (and the palate of the upper cast) are covered with a single layer of baseplate wax. A layer of tin foil, which is lubricated with microfilm, is burnished over this wax spacer. Another layer of baseplate wax is then adapted over the tin foil. The borders of the wax should extend to but not beyond the reflecting soft tissues.

The intraoral central bearing plates and the central bearing screw are positioned in the wax on the casts. It is ascertained that articulator excursions can be made

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with the only contact between the upper and lower parts being at the central bearing point and the central bearing plate.

The extraoral parts of the tracing device are then luted to the wax and tested for good alignment. After this is done, the detachable female parts are removed (Fig. 1).

Fig. 1.

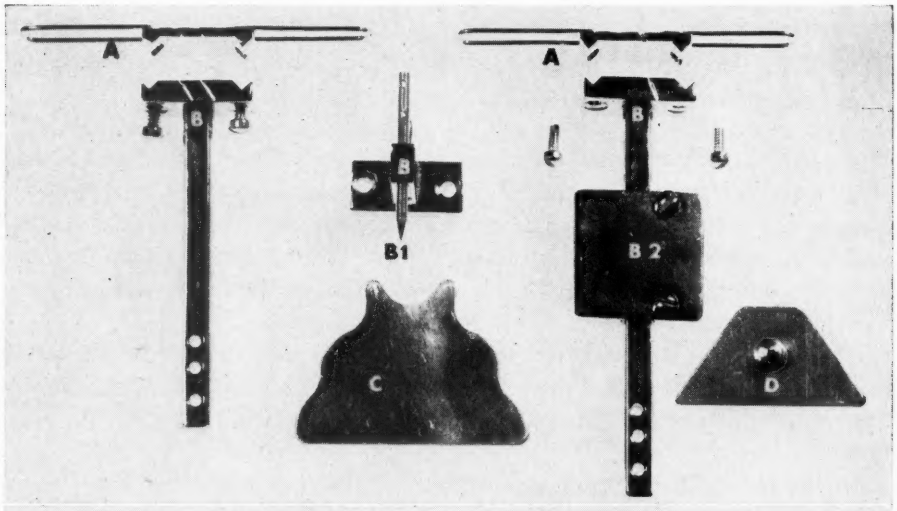


Fig. 2.

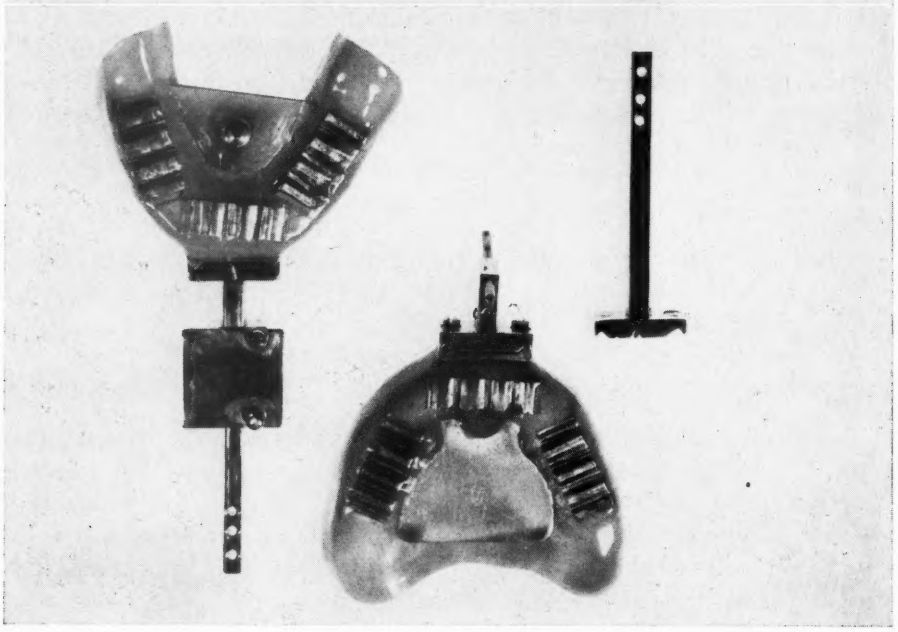

Fig. 1.—The tracing device disassembled. *A*, The male part of the detachable studs with wire loops for retention in the acrylic resin. *B*, The female part of the detachable studs. *B1*, The extraoral tracing pin. *B2*, The extraoral tracing plate. *C*, The intraoral bearing plate. *D*, The intraoral bearing plate and central bearing screw.

Fig. 2.—The acrylic resin clutches with the tracing device attached are ready for use in the mouth. Note the corrugated metal cleats which key the interocclusal records.

Metal cleats for the subsequent accurate positioning of interocclusal stone indexes are pressed into the wax. (These cleats may be soldered to the intraoral metal plates if desired.)

The wax patterns are then invested, processed, and cleaned, and the female parts of the device are replaced. Then the acrylic resin clutches are ready for use in the mouth (Fig. 2).

Fig. 3.

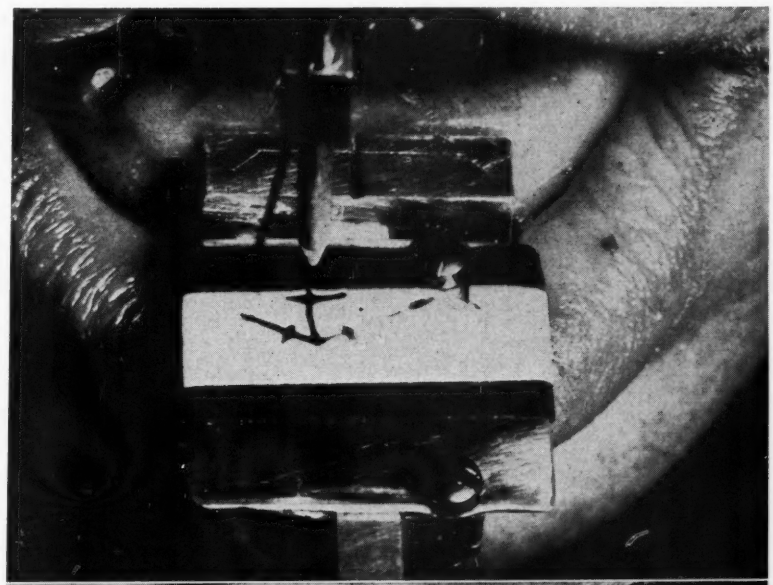

Fig. 4.

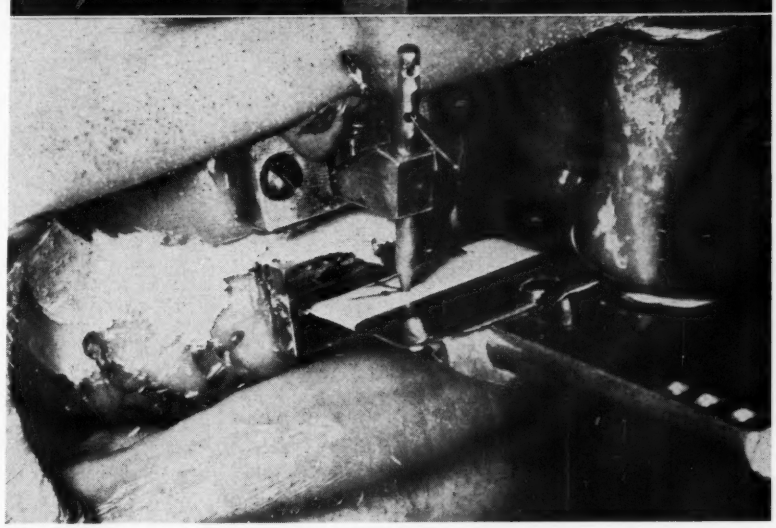

Fig. 3.—A needle point tracing and a protrusive path are marked to indicate the protrusive and right and left lateral positions.

Fig. 4.—Quick-setting stone is used to record the jaw position when the needle point tracer is in the apex of the tracing.

The clutches are filled with a thiokol impression material. It is important to adhere rigidly to the manufacturer's instructions regarding mixing and the length of time that the material must be held immobile in the mouth to insure setting without distortion. When both clutches have been inserted in the mouth, any excess material which may interfere with the free movements of the clutches must be removed. This can be done easily with sharp curved scissors.

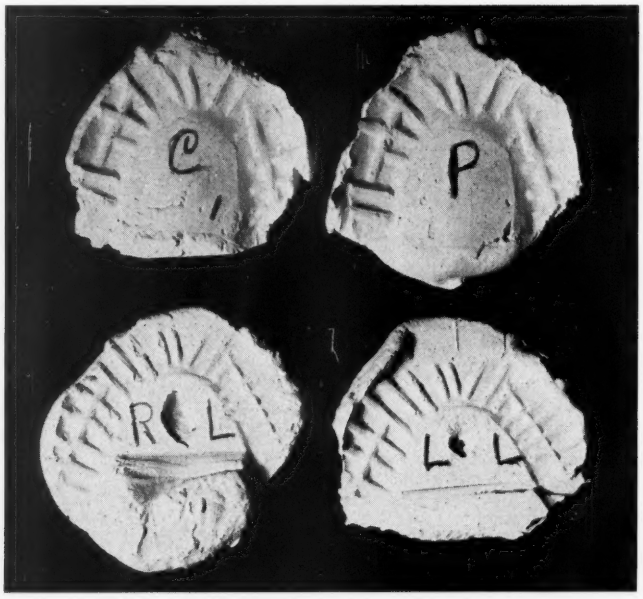


Fig. 5.—Stone interocclusal records are identified for the various jaw positions. *C*, the centric position, *P*, protrusive, *RL*, right lateral, and *LL*, left lateral positions.

## NEEDLE POINT TRACINGS AND JAW RELATION RECORDS

With the tracing device in proper contact, instructions are given to the patient to carry out the jaw movements which will result in a Gothic arch (needle point) tracing and the tracing of the protrusive path. The tracing is covered with a piece of Scotch tape to prevent its obliteration or marring as other procedures are completed.

On the tracing which has been scribed, the points that designate the protrusive and right and left lateral jaw positions, which we wish to record, are then marked off (Fig. 3). The point of the extraoral tracing pin is brought to coincide with each of these positions in turn, and quick-setting stone is introduced between the clutches, which have been previously painted with microfilm (Fig. 4). The stone interocclusal records are marked for identification and put aside (Fig. 5).

## LOCATION OF HINGE AXIS AND FACE-BOW TRANSFER

A hinge axis recording bow is attached to the lower clutch (Fig. 6), and the mandibular hinge axis is located in the usual manner. The hinge axis points and

Fig. 6.

Fig. 7.

Fig. 6.—A hinge axis recording bow is attached to the lower clutch.
Fig. 7.—A transfer face-bow is attached to the straight rod on the upper clutch. Quick-setting stone is placed around the lock screw to prevent any movement.

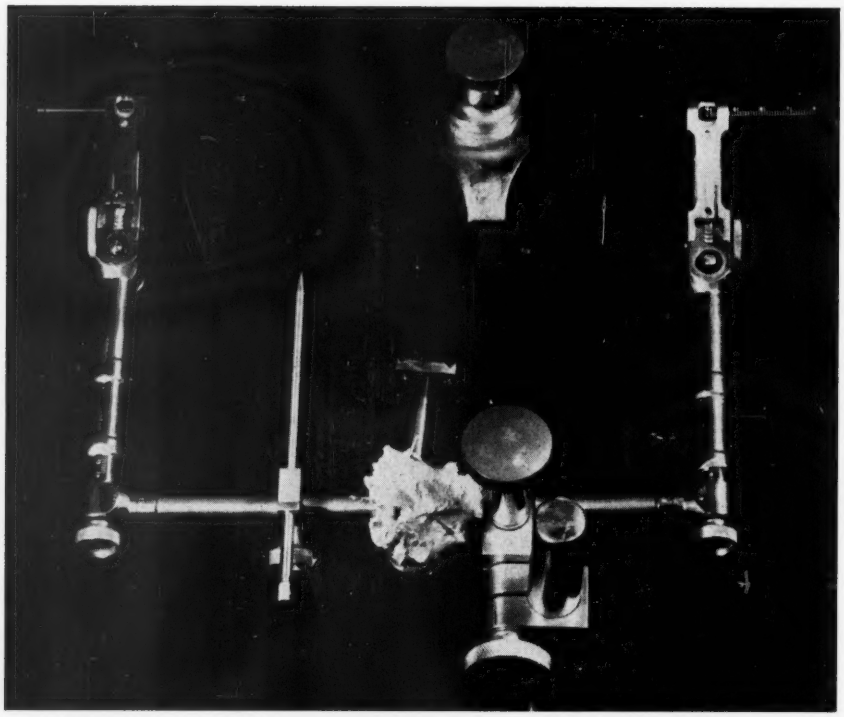

Fig. 8.—The transfer face-bow and reassembling rod are placed on the mounting rack.

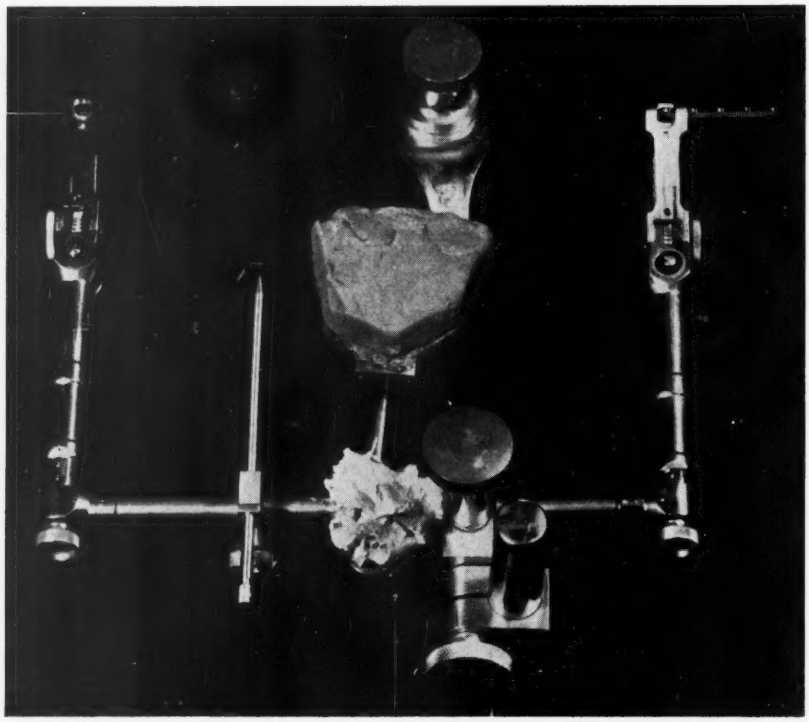

**Fig. 9.—The upper clutch containing the stone cast is reattached to the face-bow assembly.**

the infraorbital points are marked on the patient's face. The fact that the point of the extraoral tracing pin can be observed to return to the apex of the needle point tracing as the patient closes in a hinge movement facilitates the recording of the hinge axis. Then the hinge axis bow is removed.

The central bearing screw is turned up two turns to increase the interocclusal distance. A new needle point tracing is made and a stone record is made with the point of the tracing pin at the apex of the new tracing. This procedure is repeated twice. After the casts and the clutches have been mounted in the articulator, the three additional stone records are placed between the clutches one at a time and in the sequence in which they were recorded. If they are accepted by the instrument without separation of either condyle ball from its anterior stop, it may be assumed that the articulator hinge axis coincides with the patient's hinge axis.

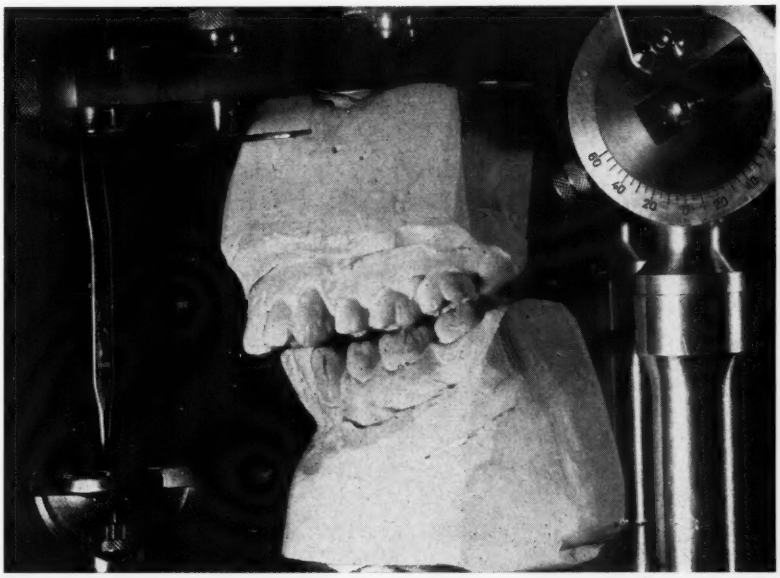

Fig. 10.—The casts are mounted, and the positional relations are adjusted by means of the stone indexes (interocclusal records). The articulator is closed to the initial occlusal contact.

The lower clutch is taken from the mouth. The detachable stud carrying the tracing pin is unscrewed from the upper clutch and a straight rod is screwed in its place. A transfer face-bow is attached to the rod and adjusted to the previously marked hinge axis reference points on the face. The face-bow is locked to the rod with quick-setting stone (Fig. 7).

This assembly is unscrewed from the upper clutch and placed in the mounting rack (Fig. 8), and the upper clutch is removed from the mouth.

## MOUNTING THE CASTS

The impressions in the clutches are poured in stone, and the upper clutch containing the stone cast is reattached to the rod on the assembly in the mounting rack (Fig. 9). The cast in the upper clutch is mounted in the articulator, and the lower

cast and clutch are related to the upper cast by means of the centric relation stone record. The articulator guidances are adjusted by means of the protrusive, right lateral, and left lateral stone interocclusal records. These procedures are carried out in the same manner as if wax interocclusal records had been used. The clutches are removed, and the casts are examined for imperfections.

The articulator may then be closed to the first tooth contact (Fig. 10), and the mounted casts may be used for working out the sequence for grinding and for subsequent use in the mouth.

If occlusal reconstruction with a restoration of lost vertical dimension is the treatment required, the articulator may be opened or closed to the interocclusal distance which is indicated, since the casts have been mounted in the terminal hinge position. The occlusal pattern may then be worked out in wax and may serve as a blueprint for future restorations. This procedure can be used after all preparations of the teeth have been completed; thus, mounted master casts of the prepared teeth can be obtained.

SUMMARY

A technical procedure has been described by which accurate casts and positional jaw relation records may be obtained at one appointment.

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# FIXED DENTAL PROSTHESIS

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In spite of the advantageous features possessed by the full coverage abutment, there are many who show some reluctance to use this type of restoration. This reluctance is probably due to one of the two following considerations.

First, there appears to exist apprehensiveness due to clinical disappointments which may have been experienced, such as pulp exposure, hypersensitivity of the teeth, and edematous tissue areas due to overextension. These unpleasant experiences can be eliminated by the adoption of a definite operative procedure in the preparation of the abutment tooth for the reception of the full coverage bridge abutment. The geometric precision of the shoulder is of inestimable aid in the development of a precise operative procedure, in addition to being required in order to achieve the biomechanical advantages of the shoulder preparation.

A second deterrent to the more widespread use of the full coverage abutment is based upon a fallacious notion of the time and difficulty of the preparation of a tooth for a jacket preparation.

At one time, this idea was valid. However, this was in a day when the armamentarium was not as adequate for the procedure as it is today. As will become very evident in the procedure which is to be presented, the time required to prepare a tooth to receive a full coverage abutment will be well within that required for a compound inlay or a ¾ crown.

## THE ARMAMENTARIUM AND PROCEDURE

A few observations relating to the contemporary armamentarium and procedure are pertinent. Diamond instruments, sometimes referred to as diamond stones, are used extensively. These instruments mark a significant advance in more efficient operative procedures due to the variety of their design.

In the past, the principal function of the contra-angle handpiece was to permit engine operation in regions which were accessible only with difficulty by means of the straight handpiece. However, in recent years, engineering design of the contra-angles has been so improved that the contra-angle no longer need be used only when necessary. As will be seen, the exclusive use of the contra-angle makes any surface more readily accessible by a mere twist of the handpiece and a slight movement of the wrist, and it has the added advantage of greater visibility. This ability to approach all tooth surfaces with ease also permits the dentist to avoid the uncomfortable back-straining positions so often required by straight handpiece operation.

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INSTRUMENT SPEEDS

There has been considerable discussion relative to the use of high instrument speeds, in order to take advantage of the marked increase in cutting efficiency, which dental instruments show as their speed is increased. In clinical procedures, the mechanical efficiency of the instrument is but one of the considerations of the conscientious dentist. He must at all times have control over the instrument. With the relatively high torque characteristic of the usual dental engine, a momentary loss of control is likely to prove disastrous, or at least cause unnecessary trauma. A low torque dental engine is available, and this may make possible safe use of very high speed dental instruments. However, the equipment employed by most dentists is best operated at a moderate speed. The determination of the speed at which the instrument should rotate will be a function of the individual dentist. A dentist blessed with a firm, resolute hand and a fast reaction time obviously can operate more safely at higher engine speeds than a dentist who is not so endowed.

The operation may progress more rapidly if the tooth being prepared is maintained free of debris and prevented from heating.

During the early stages of the operative procedure when gross preparation is in progress, minute details are not of the utmost importance, so that advantage can be taken of the high specific heat of water and a flavored mouth wash used as a coolant. The coolant should be so directed as to maintain a clear field. Since it is important that the dentist be able to observe clearly all details of the work, especially during the later stages of the preparation, the field is more satisfactorily maintained clear and dry by a steady series of short blasts from the air syringe.

TECHNIQUE OF TOOTH PREPARATION

A lower left cuspid will be used for the purpose of illustrating my procedure for the efficient reduction and preparation of a typical tooth for the reception of a full coverage abutment with a plastic veneer.

The instrument used for the initial reduction of a tooth, is a No. 76 diamond wheel (Fig. 1). This instrument has rounded edges which is an important feature in the design, since this precludes the likelihood of producing sharp angles or undercuts in the preparation. These sharp angles and undercuts are always difficult to remove. This diamond wheel is used to remove buccal and lingual contours and to reduce the occlusal or incisal edges. During this process, as much of the enamel as is accessible is removed.

The second stage of the procedure might be looked upon as the concluding phase of the tooth reduction and the first stage of the preparation (Fig. 2). For this purpose, the concave disk cutting on the outside is particularly effective. Due to the design of the wheel, sharp axial angles and undercuts are easily avoided.

The instrumentation used in the final reduction and initial preparation of the mesial surface is shown in Fig. 3. Due to its broad cutting surface, this instrument should be used with a light brushlike motion so as to minimize trauma. The small wheel is superior to the cylindrical point for reducing the labial and buccal surfaces and enhancing the definition of the shoulder without introducing undercuts and sharp angles (Fig. 4). To reduce the tooth substance and carry out

the initial stages of the preparation, we have used a disk and two wheels. The tooth has been given a slight taper and a shoulder has been developed. At no time have we traumatized the soft tissues surrounding the abutment; this is a feature which cannot be overemphasized. Experience has proved that a disappointing result in the finished jacket can often be traced to traumatized tissues during the preparatory procedure. If tissues are traumatized, the dentist is not only confronted with unclear fields but also an unsatisfactory final result. This is due to the effects of the healing process on the soft tissues.

Fig. 1. Fig. 2.

Fig. 3. Fig. 4.

Fig. 1.—A diamond wheel is used for gross reduction of tooth substance.
Fig. 2.—A concave disk is used for outside cutting.
Fig. 3.—The concave disk is used for the initial preparation of the proximal surface.
Fig. 4.—A small wheel instrument is used for labial and buccal surface reduction without producing undercuts.

## FINISHING AND REFINING THE PREPARATION

In order that maximum detail can be observed, we change from water to air as a coolant and field-clearing medium (Fig. 5). The mandril type of instrument is used first at this stage of the preparation. This instrument should have as its only function the smoothing and finishing of the preparation in order to add some refinements and to emphasize the shoulder outline. Starting with this stage, no gross removal of tooth structure should be necessary. If this necessity should reveal itself due to an inadequate initial preparation, it is more efficient practice to use the instrumentation recommended for the initial preparation. During this

refining stage, the shoulder should be fully developed and the shoulder outline should be extended below the free gum margin. The depth to which the shoulder should be extended is determined by the amount of free gingivae. A shoulder of excessive width should not be produced, and a depth so great as to encroach in any way upon the gingival crevice should be avoided.

Fig. 5. Fig. 6.

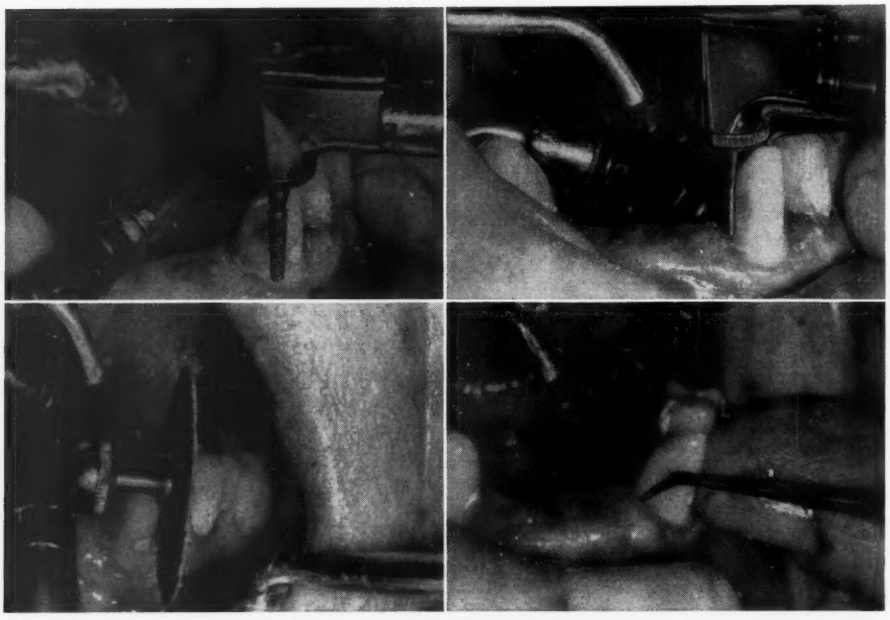

Fig. 7. Fig. 8.

Fig. 5.—Mandril type instrumentation is used in finishing the stages of the preparation. Note that air is used as a coolant and for clearing the field.

Fig. 6.—An end-cutting bur is used to define and smooth the shoulder.

Fig. 7.—A carborundum disk is used to smooth the surface of the preparation.

Fig. 8.—A "Bisco" hoe, 12-6-12, 212 or 8-3-12, 217, is used to produce the fine detail of the shoulder.

After the shoulder has been fully developed, its definition and smoothness can be improved by the use of the end-cutting burs Nos. 900 and 901 (Fig. 6). The application of this instrument should be in a light sweeping motion along the plane of the shoulder. This instrument should never be permitted to rest on one area of the shoulder. Craftsman carborundum disks are used with a very light pressure for the final smoothing of the surfaces of the preparation (Fig. 7).

The final detail of smoothing the shoulder and producing a fine outline and definition by the use of the hoe is illustrated in Fig. 8. It is often advantageous to use a finishing stone as an additional refining operation on the shoulder surface. A shoulder with fine outline and definition is a great aid in that it provides a positive guide for the evaluation of the impression and as an indicator for seating the casting.

There is much to be gained from a systematic study of that which is to be accomplished and then developing and adhering to a definite system of procedures to accomplish the desired end. Because of the wise choice of instruments and because the objectives to be accomplished by each step were clearly established, the full coverage abutment preparation described above was prepared with precision and facility.

## THE IMPRESSION PROCEDURES

In the impression procedure for the accurate reproduction of the preparation, a stepwise analysis of the required goals at different stages will permit the dentist to proceed directly from one stage to another without any lost motion. This will produce an accurate and detailed impression of the preparation. High heat modeling compound is so satisfactory for this purpose that it is the material of choice for this type of impression.

The selection of the proper annealed copper band is no less important than any other phase of the impression-making procedure. The band must fit the tooth tightly. The importance of this cannot be overemphasized. Unfortunately, the common practice is to use an oversized band which permits some of the soft tissue to be included in the impression inside the copper band. This is an error which dooms the restoration to failure. In order to establish the proper cervical outline and make the impression, it is necessary to remove the copper band from and return it to the mouth several times. Accordingly, some means must be provided to locate the band readily and accurately in exactly the same relationship to the tooth on each occasion. Fig. 9 shows a means of identifying the band for this purpose. One surface of the band is perforated to indicate the labial or buccal side and the incisal or occlusal end of the band.

The band with its perforation in the index position is seated on the tooth after the gingival end has been trimmed to the contour of the gingival margin. The dentist's judgment is used in this trimming which is merely a step toward the proper trimming. For the best registration of the preparation, it is necessary to trim the cervical outline accurately. For this purpose, the copper band is filled with a soft counter wax and seated on the tooth (Fig. 10). In making this impression, the band should be seated first by applying pressure with the fingernails on the incisal end of the band after seating by applying moderate pressure to the wax. The wax is chilled, and the impression is removed. The counter wax impression clearly indicates the regions in which the band is overextended (Fig. 11). This preliminary impression will also indicate whether or not any undercuts exist in the preparation, since their presence would cause the wax to drag. The definition of the shoulder is also clearly registered.

A critical inspection of this wax impression will indicate whether any corrections should be made to the preparation before proceeding to make the final impression. The overextension of the band is corrected by the use of crown and bridge scissors. During this removal of the overextended region of the band, some roughness is likely to be produced on the gingival edge of the band. This roughness might injure the periodontal fibers, so the band should be smoothed with a

gold file (Fig. 12). A second trial impression is made in counter wax (Fig. 13) in order to make sure that the band has been properly trimmed and that the preparation does not possess any defects such as undercuts or poor shoulder definition.

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

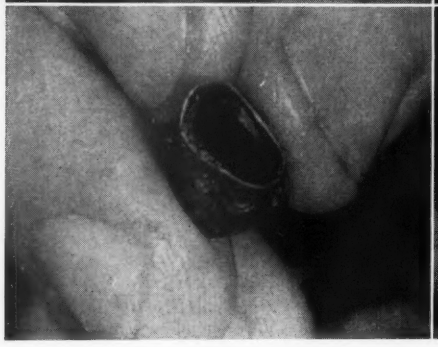

Fig. 14.

Fig. 9.—A perforation is made on the buccal surface of the copper band at its incisal end for orienting the band on the tooth accurately.

Fig. 10.—The copper band is filled with counter wax and seated on the tooth. Then a slight pressure is applied on the wax for a preliminary impression.

Fig. 11.—The preliminary impression in wax determines the need for additional trimming of the gingival margin of the copper band.

Fig. 12.—The gingival margin of the copper band is smoothed with a gold file after it is trimmed.

Fig. 13.—The second wax test impression shows that the gingival margin of the band is properly trimmed and that the preparation is adequate.

Fig. 14.—The compound-filled copper band is seated by the pressure of the fingernails on the incisal end of the band, and after the band slips past the shoulder, pressure is applied to the modeling compound.

The counter wax is melted from the band, and modeling compound is introduced into it by first filling the incisal or occlusal end with the heated compound and then filling the gingival end of the band. The fingers should be lubricated with petroleum jelly to prevent its adhesion to the fingers. The band is first seated securely into its proper position on the tooth by applying moderate force with the fingernails on the band until it is felt to slip over the shoulder preparation. Pressure is applied to the modeling compound as soon as the band is properly seated (Fig. 14). Finger pressure is applied directly to the compound. After chilling with tap water, the impression is ready for removal.

A towel clamp is used to remove the chilled impression (Fig. 15). This will prevent distortion of the impression by improper removal. The impression can be gripped securely by the pointed tongs of the towel clamp, and the entire assembly can be held by the finger rings of the towel clamp without any twisting or rotation. The index finger of the other hand is placed under the tines of the clamp and used to exert a steady force on the impression parallel with the long axis of the tooth, thereby effecting the distortionless dislodgment of the impression from the tooth. All detail has been faithfully recorded in the final impression, which is one of the prerequisites for a successful restoration (Fig. 16).

Fig. 15.

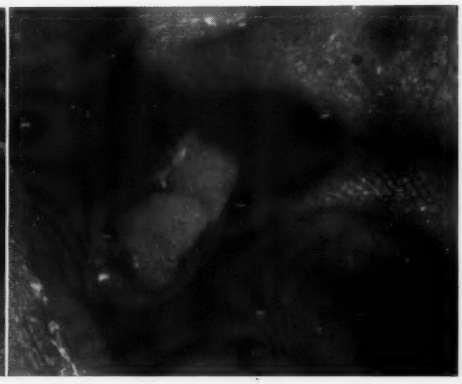

Fig. 16.

Fig. 15.—A towel clamp is used to assist in the removal of the impression and avoid its distortion.

Fig. 16.—The final impression.

## THE DIE

A die which accurately reproduces every detail of this compound impression must be fabricated. We have found the copper-plated compound impression in a copper band to give the most consistently satisfactory results.

The only troublesome step in the process is the preparation of the impression surface so as to render it electrically conducting. The entire surface of the impression must be treated, and any pooling of the conducting material in impression details must be meticulously avoided. This part of the procedure can be efficiently

carried out with the Barnett copperizer silver base. This material must be applied rapidly since the liquid used to disperse the powdered metal is extremely volatile, and too slow an application can result in defects and less than normally smooth surfaces.

TRANSFER COPINGS

The tail pieces for the die are most satisfactory when they are fabricated of low-fusing metal. This metal provides the adequate support needed by the electroplated shell; it is readily fashioned into the desired shape, and it possesses the toughness needed to prevent accidental breakage.

Fig. 17.

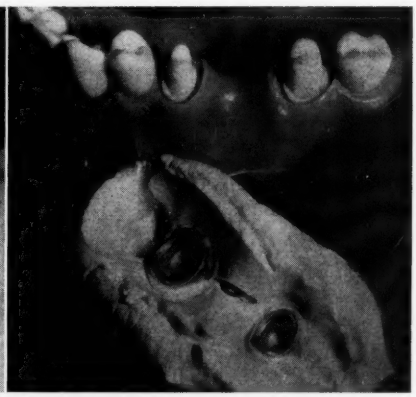

Fig. 18.

Fig. 17.—Low-fusing metal transfer copings with grooves to guide their positioning in the impression.

Fig. 18.—A plaster impression with the transfer copings in place.

An indexing method to locate the dies accurately in the master working cast must be used. For this purpose, we have adopted the low-fusing base metal transfer coping. These copings have the advantage of a great saving in time and material with no sacrifice in accuracy.

To fabricate the transfer coping, the junction of the copper-plated surface and the root portion of the die are painted with a thin past of yellow ocher* dispersed in wood alcohol. This will prevent the base metal of the transfer coping from adhering to the die metal if it should happen to run past the shoulder onto the root portion of the die. A piece of ¾ inch masking tape is adapted around the part of the die which has been painted with the yellow ocher. It is placed so it will extend onto the root portion approximately 3 mm. The taper of the root portion of the die will cause the masking tape to assume a funnel shape.

The transfer coping is poured in Baker B metal which has been melted in a ladle-shaped spoon. During the pouring, the die should be grasped firmly with a pair of formed tweezers. After the metal freezes, the coping is tapped off the die, reseated, and finished down as those in Fig. 17. The occlusal surface of the transfer

*Yellow ocher is available at any paint store.

coping is grooved for an index and undercut around its occlusal aspect. These grooves help to retain the transfer copings in the impression. In case it is necessary to fracture the impression, the copings can be reseated accurately in the impression when it is reassembled (Fig. 18). This impression is boxed, and the dies are

Fig. 19.

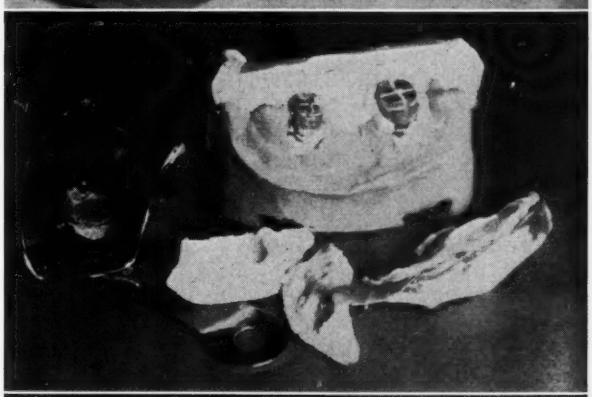

Fig. 20.

Fig. 21.

**Fig. 19.—The plaster impression is boxed and the dies are positioned in the copings.**
**Fig. 20.—A stone cast is poured.**
**Fig. 21.—The gold foil matrix is swaged on the die.**

luted in the transfer copings (Fig. 19). A stone cast is poured in this impression, the impression is separated from the stone cast, and the transfer copings have been positioned with accuracy (Fig. 20).

Fig. 22.

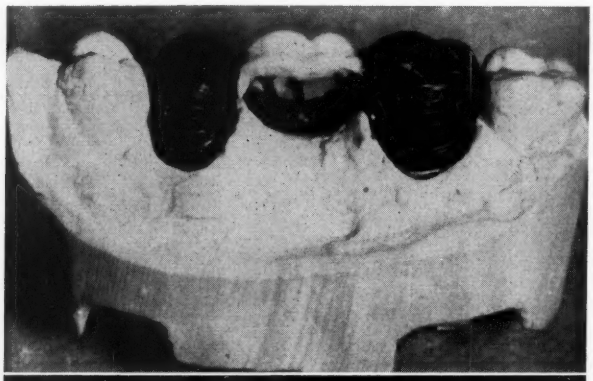

Fig. 23.

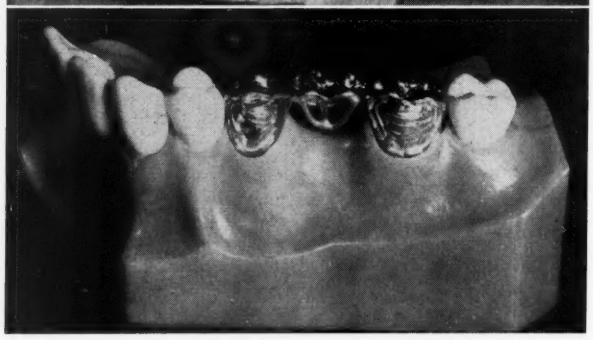

Fig. 22.—The wax pattern of the pontic and the abutment veneer crowns. Note the retention loops for the plastic veneers.

Fig. 23.—The castings are finished and the pontic is adjusted.

After the cast is mounted on the articulator, the wax patterns of the jacket crowns can be carved. The most accurate patterns are produced by waxing over a gold foil matrix. For this purpose, we use a 22 karat dead soft 0.001 matrix gold. A tinner's joint is used in wrapping the matrix which is swaged into position before proceeding with the wax-up (Fig. 21). Either a rubber mold is used to preform the wax pattern for the pontic or a ready-made cast gold pontic* is used. The wax patterns of the abutment restoration are undercut for the reception of a veneer, and small retainers in the form of retention loops are placed in the axial angles (Fig. 22). With the waxing of the pontic and abutments completed, the usual casting procedure is employed for the casting.

## ASSEMBLING THE CASTINGS

The castings are fitted in the mouth individually (Fig. 23), and the final impression is made with the abutments in position. The plaster impression is boxed

*Ponton.

(Fig. 24) and poured with a refractory investment material so that soldering can be done directly on the cast. This will minimize the inaccuracies and assure a better fitting restoration. The soldered restoration should be tried in the mouth at this time for checkup before making the plastic veneers.

Fig. 24.—A plaster impression of the castings assembled in the mouth is made for obtaining a refractory cast for soldering. Note the boxing.

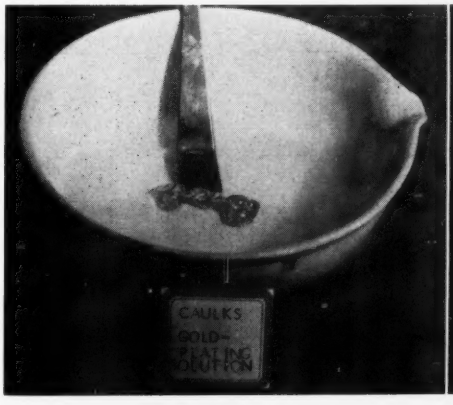


Fig. 25.

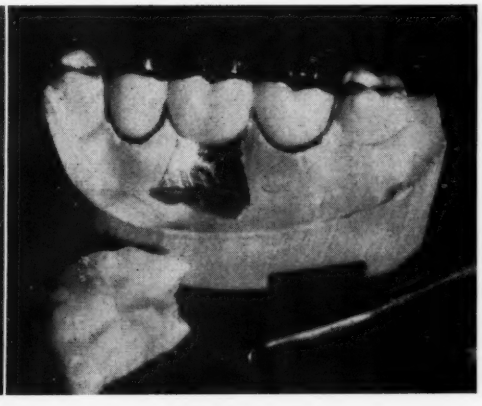

Fig. 26.

Fig. 25.—The assembled restoration is flash gold plated.
Fig. 26.—The wax patterns for the veneers and the pontic are carved on the cast.

## THE PLASTIC VENEERS

It is not easy to achieve a proper color result in plastic veneers due to the thinness of the veneers as contrasted with the bulk present in the pontic. Two processes have been developed which have solved this problem. They are the flash gold plating of the gold structure (Fig. 25) followed by the use of one of the improved opacifiers which are available today. After the gold flash plating is applied, the veneers and the pontic are waxed and carved to the usual anatomic requirements (Fig. 26).

Stone is poured into the abutment castings, and dowels are imbedded in this stone before the bridge is invested for the substitution of the acrylic resin. The dowel pins are imbedded in the abutment castings before the bridge is invested to prevent the bridge from "floating" during the investing and packing procedures (Fig. 27).

Fig. 27.

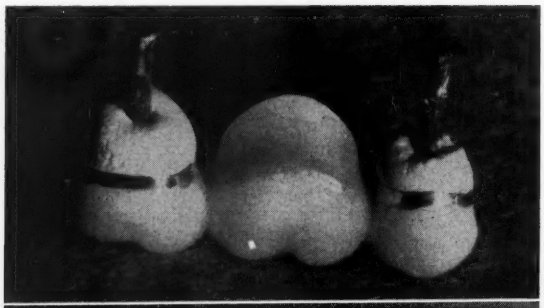

Fig. 28.

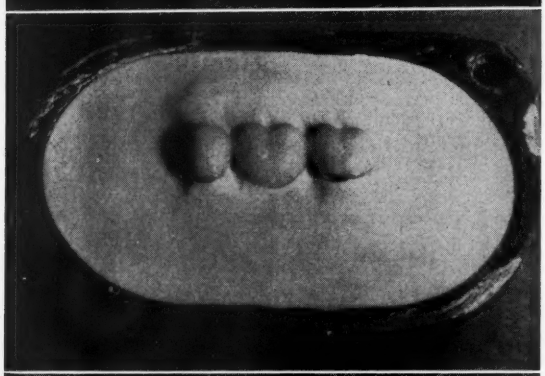

Fig. 29.

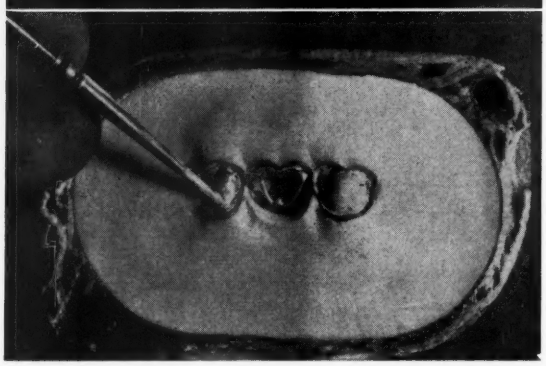

Fig. 27.—Stone is poured in the abutment castings, and dowels are inserted to aid in the investment for the processing of the veneers.

Fig. 28.—The wax patterns of the veneers are exposed.

Fig. 29.—The wax is removed and the opaque resin is applied over the gold.

The bridge is flasked (Fig. 28). The wax has been boiled out before the opaquing material of the proper hue is applied (Fig. 29). The darker colors are used for the body portion, and lighter colors are used for the incisal areas. The plastic is cured, and the bridge is recovered from the investment. Finishing should

be with burs rotating at a moderate operating speed. Operation at high speed is likely to produce sufficient heat to cause some depolymerization of the acrylic resin. Burs also maintain a certain texture of the plastic, so that it will not look artificial because of the light reflection that occurs when the surface is too smooth and highly polished. The bridge is then ready for a final try-in and cementation.

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# PONTIC DESIGN

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THE DESIGNING OF PONTICS continues to be controversial both as to materials employed and the concept of morphology. Widely divergent methods of teaching and practice are in evidence throughout this nation and the world.

Pontic form is extremely important. However, success of a bridge can be attained only when correct form and materials are combined in a well-engineered pontic design capable of meeting the exacting factors of durability and the maintenance of health and cleanliness.

## PONTIC MATERIALS

Porcelain, despite certain unfortunate properties, remains a standard as a component part of pontic construction. Glazed porcelain was the material originally applied to the advanced concept of pontics. No substitute for high-fusing porcelain has as yet proved to be completely satisfactory.

Why then, if this is true, has porcelain not become the universal material used in pontic design? The answer to this paradox seems to be that porcelain has characteristics demanding exacting consideration when it is incorporated into pontics.

Color, form, and texture of natural teeth are readily reproduced in porcelain. While these factors are extremely important, it is the remarkable tolerance of gingival tissue, when contacted by glazed porcelain, that has played an important part in advanced fixed bridgework. The high tolerance of gingivae to glazed porcelain when they are in permanent contact is the true key to advanced fixed prosthodontics.

No other material employed as a substitute for tooth structure has proved capable of sustaining a state of health and sanitation comparable to that of porcelain. This assertion may be contested, but comparison of fixed restorations in the mouth would quickly prove the point. Once this status of porcelain is conceded, porcelain becomes an indispensable material in the fabrication of the modern fixed prosthesis.

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The opinions or assertions contained herein are those of the author and are not to be construed as official or reflecting the views of the Army Department or the United States Army at large.

Read before the American Academy of Crown and Bridge Prosthodontics, Chicago, Ill., Feb. 2, 1957.

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The failure of porcelain to be in more universal use undoubtedly results from the exacting manipulation it requires and its low elastic limit when under stress.

This low elastic limit presents a formidable engineering problem when porcelain is combined with a gold alloy to form the pontics. The fact that this problem can be solved is evidenced by the fact that bridges so constructed have functioned over very long periods of time without failure of the porcelain facings.

A simple law of engineering demonstrates that all structures are deformed under the influence of force. The fixed partial denture is no exception to this law. It is necessary to design the entire pontic in such a way that the porcelain is in a neutral axis, i.e., in an area where there is neither tension nor compression.

Designing restorations that are very small in relation to the forces applied to them is a challenge in bioengineering. When porcelain is a component of the pontic structure, the design must give assurance that strains beyond the elastic limit of the porcelain are not transmitted through the gold backing to the facing. With this engineering concept in mind, it is obvious that the porcelain facing plays little if any part in resisting the forces of mastication.

Few dentists will contest the advantages of porcelain when they are applied to fixed prosthodontics, but all are familiar with the exacting technique and skill that must be exercised in its use.

Porcelain facings that will satisfy all of the engineering demands of good pontic design have not been available to the profession. Dentists and technicians have been compelled to devote great time and effort in remodeling and adapting inadequate facings. Compromises, under these conditions, cannot be avoided, and early failure of restorations may be the result.

A research project at the School of Dentistry, University of Southern California has been devoted to the development of improved facings for fixed bridgework. The objective of the research is to develop an improved design and to make improved facings available (Fig. 1).

The new facings may be used with simplicity and speed. They lend themselves to the development of scientific pontic form and greatly reduce the laboratory time expended in fabrication of pontics.

The enamel surfaces about the necks of the natural teeth are the regions normally overlapped by the free gingivae and the interproximal papillae. The examination of many extracted teeth reveals that this surface of the enamel universally displays many minute developmental undulations. While this region of the tooth is wavy and irregular, it is free of pits and roughness. The areas beneath the contact areas are even more prone to display an undulated surface.

It is possible that this irregularity may assist in the function of stimulating the gingivae and in the elimination of debris from the gingival crevice and the region of the interdental papillae.

Gingival tissue must be subjected to stimulation to have its health maintained. This stimulation is normally provided by the contact of food, cheek, tongue, and toothbrush. As movement of the gingivae takes place over the irregularities of the enamel surface, these undulations may provide additional stimulation and assist in the elimination of debris from the gingival crevice.

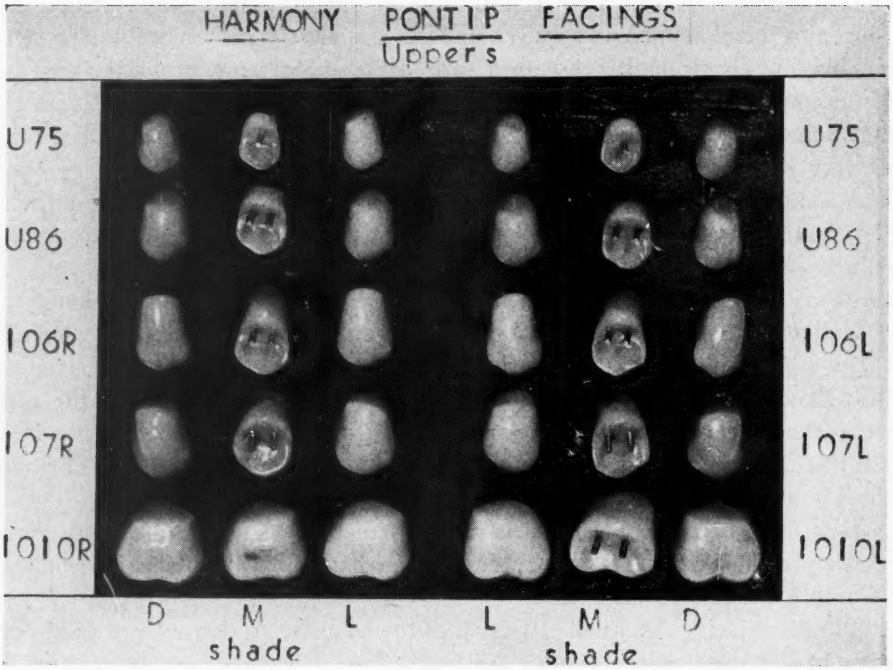


Fig. 1.—A few of the new facings.

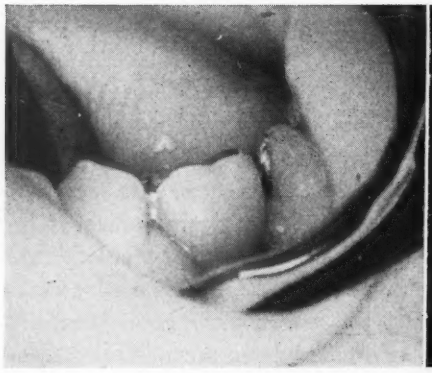

Fig. 2.

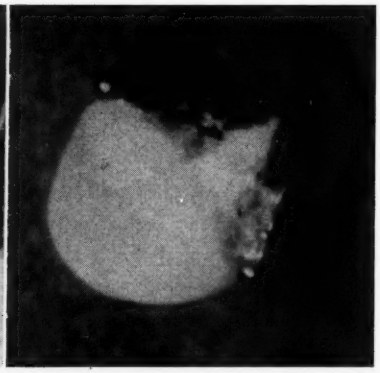

Fig. 3.

Fig. 2.—A bridge that has failed but without loosening at either abutment. Caries at the mesial gingival area of the molar abutment and the pathologic condition about the pontic indicated the removal of the bridge.

Fig. 3.—The pontic, though glazed, has caused an inflamed, foul, and hypertrophic condition about the gingival tissues it contacted. There was an excessive amount of contact with the soft tissue, denying these underlying tissues adequate stimulation and placing the porcelain in permanent contact with the mucous membrane. Mucous membrane must never be continuously contacted, even with glazed porcelain.

In designing pontics, we must be concerned with the form and nature of the gingival contacting area. The conformation of this surface must not deny access of stimulation to the underlying gingival tissue. Violation of this rule can be disastrous (Figs. 2, 3, 4, and 5).

It is only logical that a substitute for enamel should display surface characteristics closely resembling the surface of normal enamel. High-fusing porcelain, when correctly glazed, will display surface traits remarkably close to those of a natural tooth. The fact that porcelain reproduces the appearance of the natural tooth so faithfully may be partially attributed to its enamel-like surface texture.

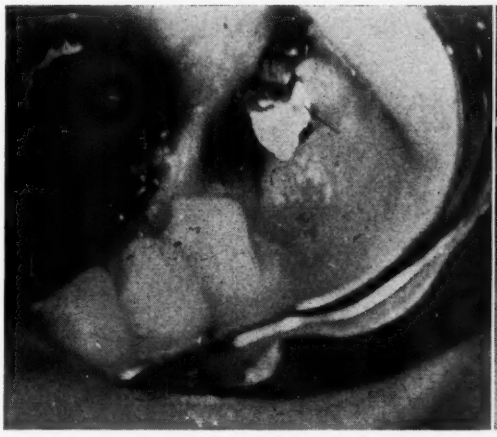

Fig. 4.

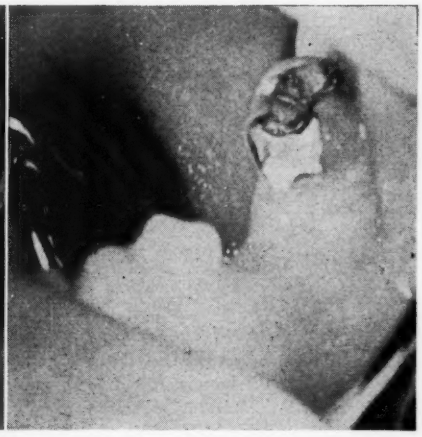

Fig. 5.

Fig. 4.—The response of this tissue to this contact is evidenced by the inflammatory, hypertrophic reaction in the mucous membrane under the pontic.

Fig. 5.—The inflammation under the pontic disappeared after the bridge had been out several days.

## OVERGLAZING

Low-fusing porcelains and overglazes have proved to be unfit for use in the mouth. The failure to recognize the shortcomings of these materials has contributed to the failure of many bridges that might otherwise have given long periods of good service. The failures of low-fusing porcelains and glazes should eliminate their use in fixed bridgework. The persistent promotion and sale of such an overglaze has done damage not only to patients but to the reputation of the most adaptable and reliable material now available to the dental profession.

When a pontic surface composed of low-fusing porcelain disintegrates, it becomes rough and porous and is the most undesirable surface that could be placed against the gingival tissue. Fortunately, there is a small percentage of mouths in which low-fusing porcelain seems to endure. Good dental practice demands the use of only the best and most reliable materials in all dental restorations. One hundred per cent success should be our objective, even though it may not always be attained.

A glazing temperature of 2,000° F. is commonly considered to be the division point between low- and high-fusing porcelain and overglazes. In the interest of safety, porcelain and glazes should be compounded to give a glazing point well

Fig. 6.

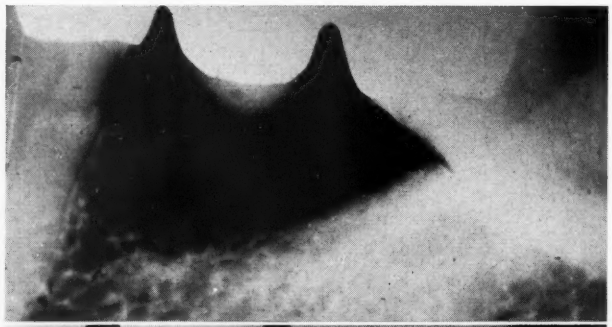

Fig. 7.

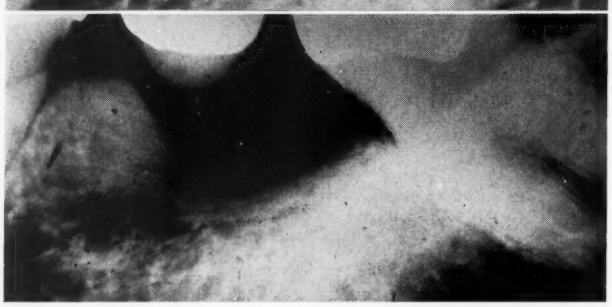

Fig. 6.—An example of the successful use of a tilted molar as an abutment. This roentgenogram was made at the time the bridge was inserted. The ovoid porcelain of the tip did not contact the ridge at the time the bridge was inserted.

Fig. 7.—This roentgenogram was made twenty-five years later. The periodontal structures appear to be in good health though the patient is past 70 years of age. Note the increase in the amount of bone on the ridge. With this increase of osseous structure, the overlying soft tissue has been elevated to contact the porcelain of the pontic. It now completely surrounds the ovoid porcelain tip. The tip is of glazed porcelain, and a state of health and cleanliness prevails in this area.

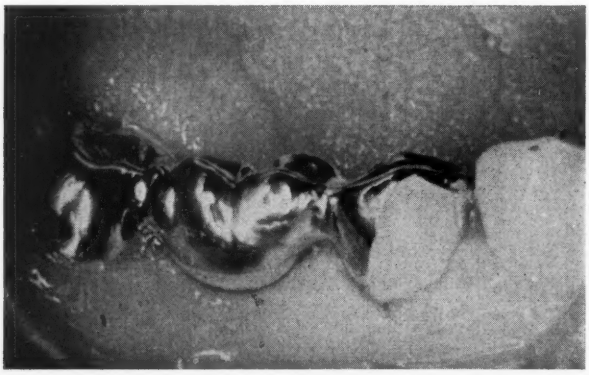

Fig. 8.—The specially designed posterior mandibular pontics have largely solved a difficult biomechanical problem of design and fabrication.

above this temperature. This will provide a reasonable margin of safety, and it will make possible a finished surface having the characteristics of the higher fusing porcelains.

At the University of Southern California, efforts are being made toward the development of an overglazing porcelain having a glazing point of 2,150° F. An overglaze firing at this temperature and displaying the surface characteristics of high-fusing porcelain is now undergoing extensive tests. A staining procedure to be used in conjunction with this glaze is also being investigated.

Overglazing implies the obtaining of a glazed surface by the application of a thin layer of a specially prepared porcelain to a ground surface. The application of a uniform layer of glaze porcelain may be facilitated by combining it with lampblack and a special mixing liquid. This procedure has been in use for over thirty years.

Obtaining a glazed surface by the overglazing method has several advantages. It may be accomplished after the bridge is completed to the point of glazing and tried in the mouth. Modification of the gingival contact, or of the labial or buccal surfaces, may be made at this time.

The lower first molar ranks high among the teeth lost at an early age. Complications arising from the tilting of the second and third molars have often led to neglect in the restoration of the first molar teeth. The successful solution of the problem of the tilted lower molar has extended the usefulness of fixed bridgework in this situation, and, consequently, it has brought about greater emphasis upon the design and form of pontics used in these restorations.

Pontics with an ovoid porcelain tip presented to the lower ridge have proved to be highly successful. The ovoid form with modification is applicable to all mandibular bridges including those restoring the anterior teeth (Figs. 6 and 7).

Whether or not the porcelain should contact the ridge at the time of insertion will be governed by the occlusogingival space and the tissue overlying the crest of the ridge (Fig. 8)

Pontic design must be adaptable to the segment of the dentition undergoing restoration. The demands of esthetics and other secondary functions must be satisfied. Prerequisites vary greatly with the location of the teeth being restored, but some are common to all. Lost teeth in the arch must be restored in a manner consistent with the original dental mechanism.

## REQUIREMENTS OF PONTIC DESIGN

Diagnosis, of course, is the most important step in bridge construction. However, there are three basic requirements which must be met in the design of pontics. First, they must promote health and cleanliness (Fig. 9). There can be no compromise in this requirement. Fixed prosthesis must promote health and facilitate the hygiene of the oral cavity. Pontics that stagnate the blood in the soft tissue and become foul and odoriferous are a travesty of modern dentistry (Fig. 10).

Second, pontics must restore a degree of function consistent with the tolerance of the abutment teeth to assume the additional load. Thorough diagnosis and good

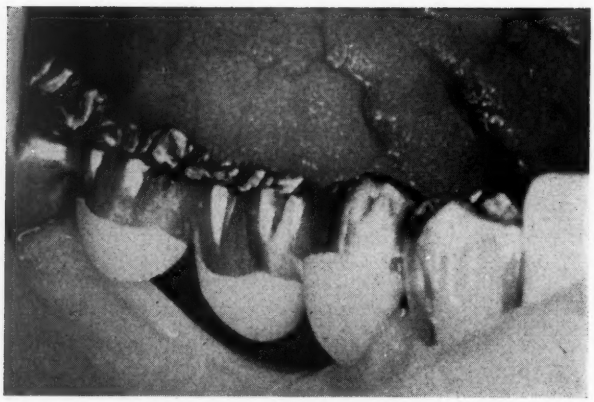

Fig. 9.—These pontics promote health and cleanliness.

Fig. 10.—A filthy bridge that has incorrectly designed pontics.

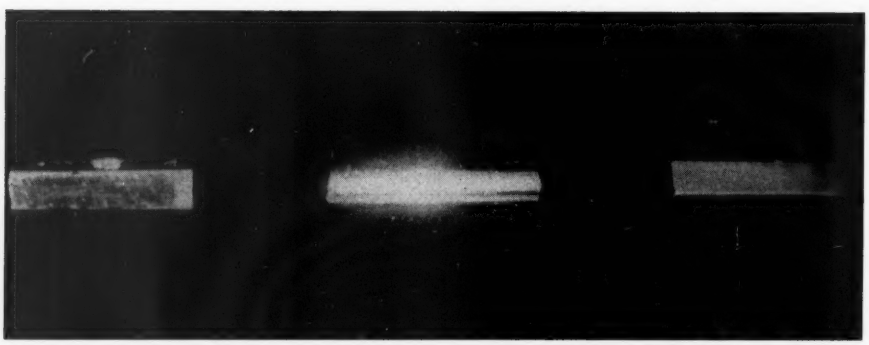

Fig. 11.—These three brass rods demonstrate the principle of reflected light. *Left,* The flat surface reflects all of the light back to the observer. *Center,* The rounded surface of the cylinder reflects light to the observer in any position. *Right,* The flat surface turned under reflects light downward and backward into the mouth, and thus away from the observer.

judgment must be combined in estimating the ability of remaining teeth to accommodate the additional load they will be called upon to carry. The secondary functional demands of esthetics, phonetics, and food manipulation must be satisfied by the conformation of labial, buccal, and lingual surfaces.

Third, the esthetic requirements imply that a pontic appear natural in form, position, and color. Obviously, the presence of gold as a part of the pontic should be concealed to the greatest possible degree. This may be accomplished by the control of the extension of metal into visible areas and the manner in which this gold reflects light. The presence of gold is detectable only when it reflects light rays to the eye of the observer (Fig. 11).

Pontics constructed in an all-out effort for esthetics invariably sacrifice strength, health, and cleanliness. Metal in contact with the gingivae, violated embrasures, and resulting irritation are common consequences of this type of compromise. Exponents of this type of bridgework may endeavor to justify its use, but they can hardly contend that such principles of construction fully meet the prerequisites of the advanced concept of the fixed dental prosthesis.

## CONCLUSION

In order for a patient to maintain good oral hygiene, to prevent the formation of plaques, and to enjoy the assurance of longevity of his fixed dental restorations, glazed porcelain presented to the gingival tissue is an indispensable factor of pontic design.

Photography by the Fixed Prosthodontic Department Film Library, School of Dentistry, University of Southern California, Los Angeles, Calif.

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Denver 8, Colorado

# RESTORATION OF BROKEN DOWN VITAL TEETH FOR FIXED PARTIAL DENTURE ABUTMENTS

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DENTISTS ARE CONSTANTLY CONFRONTED with the problem of restoring badly broken down vital teeth. Unfortunately, many teeth requiring reconstruction are not only carious teeth, but they contain large restorations which, when removed, leave the tooth with frail walls of unsupported enamel. When such conditions exist, the dentist can only restore the tooth by means of a crown.

The problem is further complicated when the tooth being reconstructed is to serve as an abutment for a fixed partial denture. If the tooth is the most posterior one in the dental arch which can serve as the posterior abutment, it is most important to retain it to avoid using a unilateral removable appliance. A definite procedure must be followed which will rebuild the coronal portion of badly broken down teeth in a manner that will give secure anchorage for an attachment.

Pins and posts have been used in dentistry for many years. They serve not only as dowels in Logan, Davis, and Richmond crowns, but also to anchor pin inlays and onlays securely. Anyone who has had any occasion to remove a well-placed pinledge attachment realizes the amount of retention derived from the use of pins.

Retention of the attachments for fixed partial dentures is essential. In order to secure retention for the attachments to badly broken down abutments, 24-gauge threaded iridioplatinum wire is used to form staples which become a part of the attachment. The staples are cemented into holes drilled in the remaining portion of the abutment tooth. They form a framework which supports and locks a cement base (Figs. 1, 2, and 3). This framework adds strength and rigidity to the restoration in the same manner as steel reinforces a concrete structure.

## THE PREPARATIONS

Roentgenograms of the abutment tooth are made at different angles so that it may be determined whether there is enough remaining tooth structure to support pins without the danger of irritating or damaging the pulp.

The holes for the wire staples are prepared in locations that will be most distant from the horns of the pulp. Whenever possible, the holes are made in pairs so that the wire can be placed in the form of a staple. This adds greater retention

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than the use of two single pins. If staples can be placed crossing one another, the retention is greatly increased (Fig. 6). In order to increase the retention and to lock the staples in position, the holes are cut at a 15 degree angle to each other rather than parallel to one another.

TECHNIQUE

A No. ¼ round bur is used to prepare the holes, extending them to a depth of 1.5 to 2.0 mm. depending on the proximity of the pulp. The holes are cut at a 15 degree angle toward the center of the tooth.

A slight scratch is inscribed on the shank of the bur to serve as a guide mark to control the depth of the holes. The bur is placed in the handpiece and revolved against a knife-edge stone in order to make this mark. Care is exercised not to cut too deeply into the shank of the bur and thus weaken it. This guide mark on the shank of the bur will eliminate the danger of cutting the holes for the pins too deeply (Figs. 4, 5, and 6).

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—Roentgenogram of an extracted broken down first molar.
Fig. 2.—A roentgenogram of the 24-gauge threaded iridioplatinum wire staples in position.
Fig. 3.—A roentgenogram showing the completed base built up with a mix of oxyphosphate of zinc cement and silver alloy filings.

A 24-gauge threaded iridioplatinum wire is used to make the staple. Heavier gauge wire or cast posts could shock or irritate the pulp. Since the size of No. ¼ round burs vary, the bur and the wire are synchronized by drilling a hole in a piece of plastic about ⅛ inch thick and then checking the fit of the bur and the wire to be used. The wire should fit into this hole fairly accurately, but not too tightly, otherwise difficulty will be encountered in cementing it to place.

The staple is cut to a length that will not exceed ½ to ⅔ of the height of the completed crown, so there will be no danger of cutting the staple when the crown preparation is made. The staple should be tried into the prepared hole in the tooth before cementing it to place to avoid any delay at the time of cementation.

CEMENTATION

Selberg* has suggested an excellent method for cementing pins. He uses a thumb reamer of suitable size, which has had the point removed, to carry the

*Alver Selberg: Personal communication.

cement into the pin holes. After carrying the cement into the holes, it is removed by rotating it counterclockwise, thereby avoiding the trapping of air in the holes and carrying the cement to the bottom of the holes.

After placing cement on the threaded wire staple, it is carried to place and forced into the holes with a suitable instrument such as an amalgam condenser. After the first staple is cemented to place, a fresh mix of cement is made, and the second staple is cemented (Fig. 6). The flexibility of the 24-gauge iridioplatinum wire makes it possible to insert the staples into the holes that are sloping toward one another at a 15 degree angle.

Fig. 4.

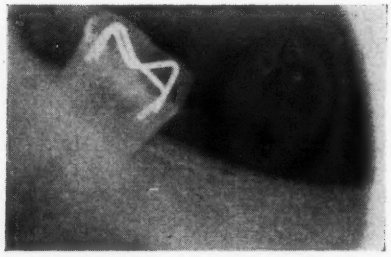

Fig. 5.

Fig. 4.—A broken down lower molar.
Fig. 5.—A roentgenogram showing the 24-gauge threaded iridioplatinum wire staples in position in holes in the tooth.

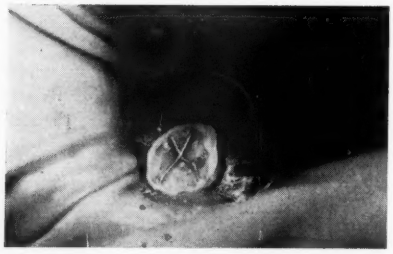

Fig. 6.—The 24-gauge threaded iridioplatinum wire staples are cemented into position in the holes in the tooth.

After the staples have been cemented into the holes, a seamless copper band is fitted to the tooth. Care is exercised to have a snug fit of the copper band at the gingival margin. The tooth is sterilized and coated with a cavity varnish. A mix of oxyphosphate of zinc cement to which silver alloy filings are added in the ratio of approximately one part of silver alloy filings to one part of cement powder is prepared. This cement mixture is carried into the band, forced against the tooth under pressure, and allowed to set for five to ten minutes (Fig. 7). After the cement is set, the copper band is slit and removed. The cement base is dressed down with sandpaper disks and mounted stones. The silver alloy filings added to the cement increase the strength and help to prevent chipping of the base when it is cut and shaped.

The occlusal surface of the cement base is cut down to follow the contour of natural cusps and to provide 2 mm. of clearance between it and the opposing teeth. The side walls of the base are cut to a slight divergence toward the gingival margin. The gingival portion of the preparation terminates in tooth structure and *not in cement.* The margin of the preparation is finished with a chamfered edge (Fig. 8).

Fig. 7.

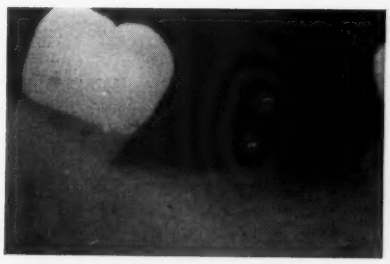

Fig. 8.

Fig. 7.—The completed base is built up with a mix of oxyphosphate of zinc cement and silver alloy filings.
Fig. 8.—A roentgenogram of the full cast gold crown in position.

Fig. 9.

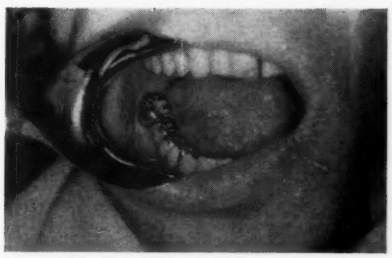

Fig. 10.

Fig. 9.—A full cast gold crown in position.
Fig. 10.—A full cast crown as an attachment for a fixed partial denture.

## DISCUSSION

The mixture of cement and silver filings is used to construct the base for the restoration, rather than silver alloy, because (1) silver alloy would cause thermal shock to the pulp when it is in so large a bulk and in such close contact with the pulp (the cement provides some insulation); (2) there might be galvanic disturbances after a gold crown is placed over the silver alloy base; and (3) since the cement needs only about ten minutes to set before the preparation may be started, much valuable time is saved.

## SUMMARY

A procedure for restoring severely broken down vital teeth has been described. Many teeth which, otherwise, may be considered too badly mutilated to be restored

to usefulness can be saved to render service over a long period of time when they are properly restored. The use of threaded iridioplatinum wire staples for the attachment of the base to the tooth, as well as for the reinforcement of the cement alloy base, makes this possible.

This procedure is effective in restoring the tooth to support an individual crown (Fig. 9), and also the restored tooth can be used safely to serve as an abutment for a fixed or removable partial denture (Fig. 10). The additional retention provided reduces the hazard of the crown loosening, and the resultant failure of the fixed or removable prosthesis is eliminated.

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## *OPERATIVE DENTISTRY*

# THE ROLE OF OPERATIVE DENTISTRY IN THE NEXT DECADE

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NO PERSON IN HIS RIGHT MIND enjoys being cast in the role of a prophet, and yet everyone enjoys a brief respite from his daily affairs to indulge in dreams. But the dreams of the operative dentist are old dreams, and they have a common root—the eradication of dental decay. It is for this reason that the operative dentist has carried the torch for those individuals who delve into research patterns of a preventive for dental decay. This has its pitfalls too, for the operative dentist, with his blind faith and naive conception of the impunity of all research workers, has been duped the same as the general public.

If the trend of exploitation of the past 10 years in the field of a preventive for dental decay continues into the next decade, an open revolt which is slowly brewing will burst into conflagration. This is as it should be, for the profession of dentistry has struggled too long for a place in the sun to see its core eaten out by facetious advertising claims and the selling of the birthright of a few unscrupulous individuals. It is true, we can pin-point the history of the dental profession on the chart of time. The early period was known as the period of *radical* dentistry, in which the order of the day was surgery. The radical period gave way to the *restorative* period, and today the restorative period is welcoming the introduction of the *preventive* period. But let no one gain the erroneous conception that a nostrum has been devised which will prevent dental caries, for it has not.

### PREVENTION OF DENTAL CARIES

In the heart of every operative dentist hope blooms eternal that a preventive will be devised. This is a true preventive and not one that is hedged with provisos. Sooner or later the concept must be spread that dental caries is a disease and that, like all other diseases, you either have it or you do not have it. In recent years, every effort has been directed at reducing the incidence of dental decay with every

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conceivable measure other than good operative dentistry. Laudable as this effort is, one cannot help but wonder why this energy is being put forth when we accept the simple fact that we cannot prevent other diseases, such as tuberculosis or syphilis. Yet the incidence of tuberculosis and syphilis in the United States has been reduced, not with nostrums but with the education of our people in the simple elements of personal hygiene.

In the world in which we live today, environment plays a very important role in one's well-being and, likewise, environment of the oral cavity plays a very important role in the maintenance of the continuity of the enamel of our teeth. The demonstrable effects of various chemicals, drugs, and antibiotics, such as iodoacetic acid, ammoniated compounds and penicillin, points up again how little is actually known of the flora of the oral cavity. Let us hope that the next decade will bring forth a definitive correlation of the well-being of the teeth with the host of physical, chemical, and biologic phenomena now at loose ends in the spectrum of our present-day knowledge.

In dealing with any unknown, there is always the danger of oversimplification, and to pass the disease of dental caries off as an environmental manifestation of neglect and ignorance is a generality of the worst order, for the genetic factor is not one to be disregarded. However, of this we may be sure; in the next 10 years the process of free selection of one's mate is not going to be relegated. Even though some states require a complete physical examination of both the male and the female prior to the issuing of a license for marriage, it is doubtful whether the dental caries index will be a disqualifying factor; and yet, the evidence is irrefutable that genetic backgrounds influence size, shape, arrangement, and quality of the teeth. This is not to say that the disease, dental caries, is inherited, for the profession has long awaited evidence of caries in a nonerupted tooth.

## MODERN INSTRUMENTATION

Just how soon the preventive era of dentistry will become a reality, no one knows; yet, with the backlog of caries incidence now present, we can be certain that the operative dentist will continue in an active practice for the next decade. For some strange reason, changes in dentistry have never come about by revolution; instead, it has been a process of slow laborious evolution. This is particularly true of the development of new instruments and new filling materials. Take, for example, the development of rotary instruments used in dentistry. Today the profession is being swept with a so-called revolutionary new handpiece that figuratively "melts the enamel." The use of high speeds of low torque is not new in industry, particularly in the jewelry manufacturing and stonecutting trades. Perhaps the reason the dental profession was so slow in accepting this departure from routine was that it required the introduction of another principle—wet field operating. It is most unfortunate that we meet up with operative dentists who will continue to carry on this inane debate of wet field versus dry field and high speed versus low speed.

The advocates of dry field-slow speed will throw up the question, "What is happening to the dental pulp with all this high speed?" The truth of the matter

is that less is happening to the dental pulp than happens when the tooth is desiccated under a rubber dam and the dentine is overheated with steel burs. Progress in operative dentistry during the next 10 years will depend upon the courage of the teachers in dental schools who will have the fortitude to stand up and practice humane dental surgery on the teeth and apply simple biologic procedures of tolerance for the dental pulp. Avoiding the use of pressure in removing enamel is humane operating, and maintaining body temperatures of enamel with a constant flow of coolant is a biologic concept beyond reproach, to say nothing of the fact that the coolant also débrides the flutes of the bur that increase its efficiency and diminish the burnishing action.

As the wet field operating technique has been accepted, other refinements of instrumentation have come along also. Noteworthy is the evacuating system for the removal of the coolant, saliva, and debris. Another refinement is the air turbine handpiece in combination with the atomized water spray. Strangely enough, the air turbine engine is not new, but for the first time in several decades, the dental manufacturers are producing for the profession what is needed and, fortunately, the market is sufficiently competitive as to eliminate the smug complacency of the yesteryears. This is a healthy sign and may bring about some sweeping changes in unit design during the next decade. Already the question is being raised as to whether or not a cuspidor is essential to a dental practice and now the need for a belt-driven engine handpiece at the chair is seriously debated.

## FILLING MATERIALS

It is in the field of filling materials that the least progress has been made. True, a new filling material was introduced in the past decade, but because of the prematurity with which it was brought onto the market, the product was not at its best. The methyl methacrylate filling of 10 years ago bears very little resemblance to the plastic filling materials on the market today. Likewise, the profession was so badly misled on these early products that there is a strong resentment against taking a chance with the newer and improved products. Perhaps the reason the profession went so overboard on the plastics when they were introduced is that it has been recognized that there is no perfect filling material.

What is more, there will be no perfect filling material until a product is devised which has the same coefficient of expansion and contraction as enamel itself. The next decade may see this development, and the greatest hope lies in the field of biochemistry. Whether this will be a process of fission of elements and the fusion of these elements into a calcium apatite molecule directly in the cavity is a moot question. Another possibility is the deposition of the calcium apatite molecule into the cavity by electrophoresis. Regardless of how it is done, it will mean a new technique for the operative dentist.

In wishing for a perfect filling material, a strange paradox arises. Will the quest for the perfect filling material antedate the preventive of dental decay? If a lozenge can be prepared, which when sucked upon for a half hour after eating can inhibit dental decay, then obviously the perfect filling material will not be needed.

Thus far we have considered three changes which might take place in the next ten years: (1) the discovery of a preventive; (2) revision of dental instruments; and (3) the creation of a perfect filling material. Now there is a fourth possibility which has to do with the conduct of operative practice. For years the practice of dentistry has been a one-man proposition, stuck up in some office building with a bleak, north-facing window. This was the situation up until a decade ago. With the conclusion of World War II, a new problem, namely, a rapidly-expanding birth rate, presented a new socioeconomic problem, and with it a new look at the physical aspect of the dental office and an even newer concept of dental practice.

## THE SOCIOECONOMIC PROBLEM

When the statistics on birth rate were first assembled, the needs for more schools became apparent. The first impact of this tide of youngsters was felt in the grade schools, then high schools. Within the next 2 years, the liberal arts college will feel it, and 4 years hence, it will be felt in the professional colleges of all descriptions. To some of the leaders of our profession, there is only one way out of this dilemma, and that is to expand the number of dental schools. A few new schools have been built, but throughout the United States the reaction to building new schools has been lethargic and this apathy is not hard to explain. From the hard, realistic viewpoint of a dental school administrator, the postwar deluge of predental students provided an opportune time to raise admission standards to a status equal and comparable to medicine. Secondly, it provided an opportunity to elevate educational standards by exacting the same proficiency of dental students as exacted from medical students. In brief, it erased any second-rate stigmata which had existed previously when students who were rejected in medicine were encouraged to study dentistry. The full impact of this upgrading of the students who are studying dentistry today will be felt in the next decade by better coexistent medical-dental relationships.

The apathy toward building more dental schools comes from another group—namely, the profession itself. This is not a selfish reaction of self-preservation. This is a very realistic reaction that stems from a military service discipline of World War II. Many men in service during World War II learned to work with a dental assistant and came to realize the value of ancillary personnel about the dental operatory. The idea of a chair-side assistant, surgical nurse, dental nurse, or call her what you will, has carried over into his practice, and the results have been astonishing. Figures in the January, 1957, issue of the *Journal of the American Dental Association* revealed that a dentist can double and triple the amount of service he renders to the public by effective utilization of ancillary personnel. When it is all said and done, it is the *production* by the dentists in a community that determines the dental health index of the community, and not the ratio of the dentists to the population.

During the next decade, it will become the responsibility of the dental schools' educators to train the dental student effectively in the utilization of the dental assistant. This will not be an easy task, for the rugged individualist will be vociferous in his condemnation that, "They are making dentistry too easy for the young fellow these days."

There are other intrinsic changes in our daily lives which are affecting dental practice. Less than 50 years ago, it was thought that there should be a dental office as far apart as you could drive a team of horses in one day. Today we do not measure distances by miles, but rather by hours and minutes, and in many states, no one is more than hour's distance from a dental office. Another interesting trend which has developed as an indirect result of better roads, better motorcars, better schools, and better communications, has been the group practice in the suburban area.

The next decade will see more of the suburban offices with their adequate parking facilities for the patient and their acceptance as health centers for the community.

## PREDICTIONS FOR THE FUTURE

As we look further into the crystal ball of the future, we see the dentist, the obstetrician, the internist, the surgeon, the otolaryngologist, and the optometrist posing in the doorway of the community health center awaiting the opportunity to be of service to humanity. Perhaps the most significant and climaxing result of the past decade is that the operative dentist practicing through the next 10 years will be able to practice operative dentistry in the highest degree of idealism with which he was imbued prior to his graduation. The new instruments and the changing concepts of practice with chair-side surgical assistance have made operative dentistry less arduous and more thrilling. With the personal satisfaction that is to come to the operative dentist in the 10 years ahead will come a greater appreciation for his skill as a specialist in the surgical treatment of dental disease; and what has been referred to in the past as "bread and butter drudgery" will rise to its rightful heritage as the "specialty of specialties." Let us pray for the responsible leadership to carry us through the decade ahead, that a new dental profession may emerge, accepted without acquiescence, recognized with reverence, and solicited for its services as a profound specialty of the healing arts.

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# SOME EFFECTS OF CAVITY INSTRUMENTATION ON THE ADAPTATION OF GOLD CASTINGS AND AMALGAM

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THE USE OF VARIOUS TYPES of rotating dental instruments and, to some extent, the manner of their use result in differences in surface irregularities during the shaping of cavities. It has been suggested that these irregularities, a cross-section of which is illustrated in Fig. 1, may affect the adaptation of the filling material to the cavity walls as well as the strength of the enamel cavosurface margins.[1] In order to gain further insight into the clinical significance of cavity wall irregularity, this study was undertaken.

## PROCEDURE

Initially, recently extracted teeth, which were intact and had been stored in neutral formalin, were used. Class II and V amalgam cavities and Class II, V, and VI inlay cavities and full crowns were prepared and finished with a variety of cutting and abrasive instruments. Normal clinical procedures were followed in restoring these teeth with the exception that no medication or cavity liner was used. Wax patterns were formed on the tooth directly, and the controlled water-addition technique for hygroscopic expansion was used for all castings.[2]

The use of natural teeth presented some problems of a technical nature, as well as difficulty in producing preparations of similar dimension and bulk for comparative study. Therefore, Ivorine blocks were substituted for teeth as a part of the study, and a series of Class I, II, VI, and full-crown preparations were made which did compare very favorably in their bulk, size, and taper. These preparations were machine-cut in a metal lathe by rotating dental instruments. The occlusal box had an outer diameter of 0.200 inches, a pulpal floor diameter of 0.175 inches and was 0.125 inches in depth; this established a 10 per cent taper. The full crowns had similar but inverse dimensions. The proximal boxes of the Class II and VI preparations were formed by maintaining the lathe stationary, entering with the revolving instrument at the proximal surface, and cutting to the axial wall depth. The lathe was then rotated by hand through an arc to cut the axial wall, and the rotating instrument was withdrawn to the proximal surface to complete the box outline.

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The adaptation of the restorative material to the walls and margins of the preparation was examined in both the natural tooth and Ivorine block by sectioning through the restoration so as to establish a profile of the restoration-wall interface. This profile view demonstrates the irregularities of the cavity wall and, with the amalgam restorations, the degree to which the amalgam may be adapted to these roughnesses. The sectioned gold castings show the ability of the wax to reproduce the wall irregularities, the wax distortion upon withdrawal from these undercut irregularities, and the casting readaptation to the cavity walls both with and without a cement luting material.

Fig. 1.—A labial-lingual section through a mandibular cuspid whose labial surface is finished with a flame-shaped diamond.

## OBSERVATIONS OF CAVITY WALL IRREGULARITY OF NATURAL TEETH

It was evident from the natural tooth specimens both microscopically, by use of shadowed collodion replicas,[3] and macroscopically that the various types of rotating instruments produce different cavity wall roughness. The degree of roughness appears to be generally in accord with the measurements taken from the profile recordings.[1] A summary of these findings (Fig. 2) illustrates the maximum roughness developed on cut tooth surfaces by diamond, lightning, and carborundum disks; various-sized cylindrical diamonds; cross-cut and plain fissure burs; and two types of finishing stones.

The cavity walls finished with the cylindrical diamond have distinct irregularities (Figs. 3 and 4). The cross-cut fissure burs present a wavy type of surface (Fig. 5).

A Proficorder chart which depicts the roughness developed by the rotating instrument on a cut tooth surface is shown in Fig. 6. Measurements were taken

from charts such as this to determine the roughnesses presented in Fig. 2. A silhouette of a cross-cut fissure carbide bur is superimposed upon this Proficorder chart illustrating the coincidence of surface irregularity with instrument design, and thus the waviness developed on the finished surface with the particular instrument.

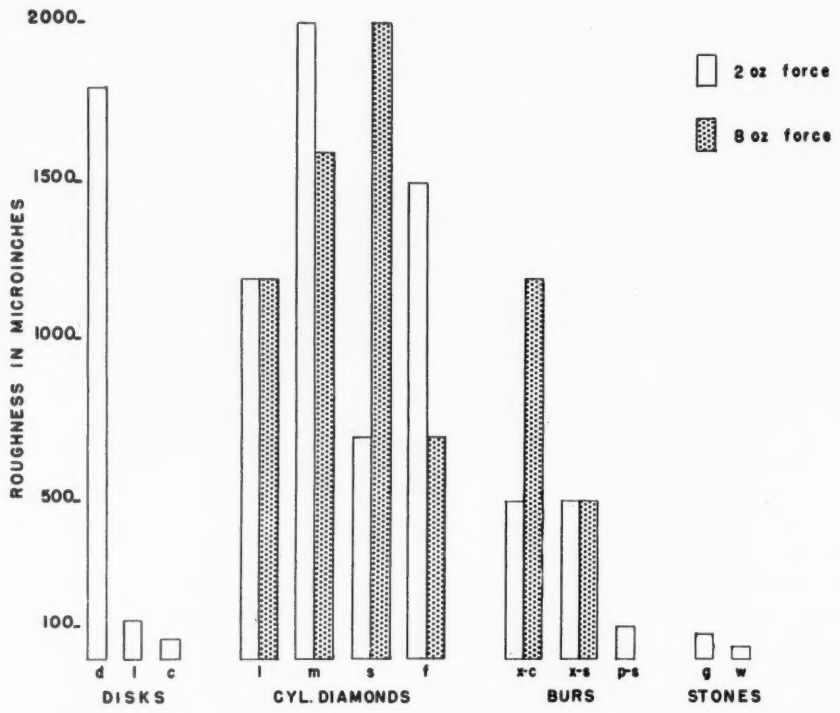


Fig. 2.—Maximum roughness developed on cut tooth surfaces by instruments rotating at 18,000 r.p.m. under an air-water spray with applied forces of 2 ounces and 8 ounces 100 microinches = 0.0001 inch.

Disks: d—diamond
l—lightning
c—carborundum

Cylindrical diamonds: l —large
m—medium
s —small
f —flame

Burs: x-c—cross-cut fissure carbide
x-s—cross-cut fissure steel
p-s—plain fissure steel

Stones: g—green carborundum finishing
w—white finishing

The cavity wall developed by the finishing stone as shown in Fig. 7 is relatively smooth. This smoothness is approximated closely by the surface produced by the plain fissure bur.

Cavity preparations finished with the cylindrical diamond, cross-cut fissure bur, and plain fissure bur resulted in the wax patterns and subsequent castings

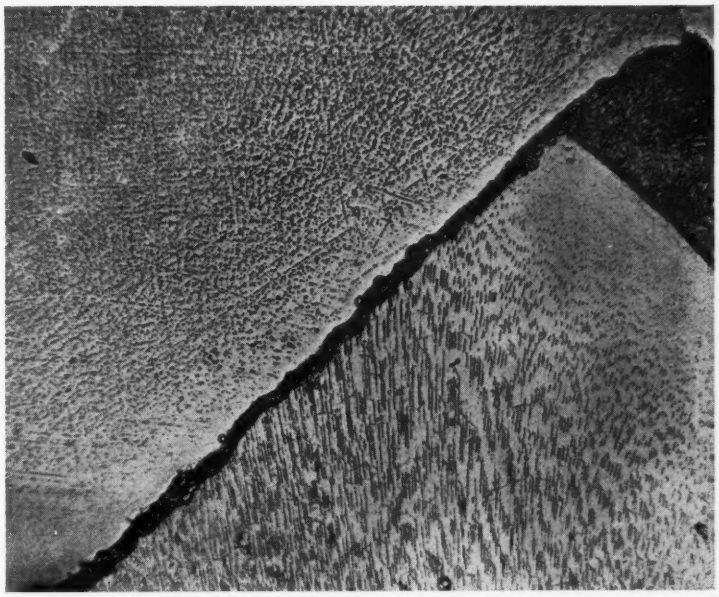

Fig. 3.—The cervical wall of a Class V inlay. The preparation was finished with a medium-sized cylindrical diamond at 18,000 r.p.m., air-water spray, light force.

Fig. 4.—The occlusal wall of a Class V amalgam. The preparation was finished with a medium-sized cylindrical diamond at 18,000 r.p.m., air-water spray, light force.

shown in Figs. 8, 9, and 10, respectively, which illustrate macroscopically the reproducibility of wall roughnesses. Note that the distinct grooves on the surface of the casting shown in Fig. 9 from the cross-cut fissure carbide bur are unevenly spaced due to the free-hand shaping of the cavity normally carried out clinically. The irregular voids on the surface of this casting have resulted from lack of wax adaptation.

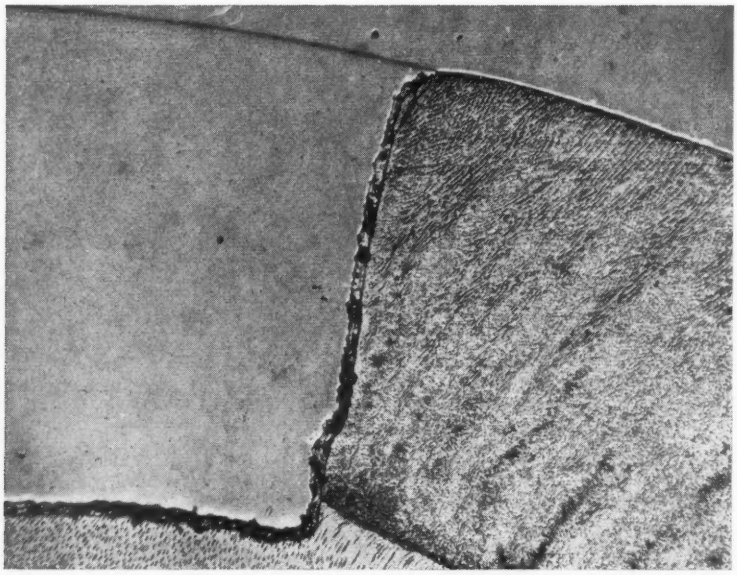

Fig. 5.—The occlusal wall of a Class V inlay. The preparation was finished with a 701 carbide cross-cut fissure bur at 18,000 r.p.m., air-water spray, light force.

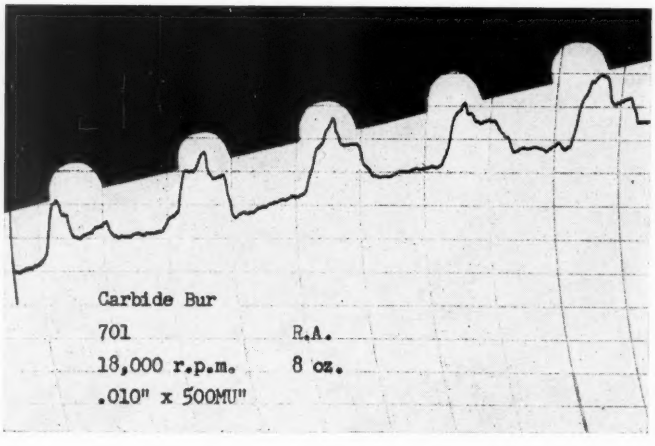


Fig. 6.—A Proficorder chart depicting surface roughness, with the silhouette of cross-cut fissure carbide bur superimposed.

ADAPTATION OF RESTORATIVE MATERIAL TO CAVITY WALLS OF NATURAL TEETH

Very good reproduction in the wax pattern and subsequent casting of the cavity irregularities is illustrated microscopically in Fig. 3. The readaptation of the cemented casting shows the corresponding irregularities in casting and wall to be very closely adjacent with approximately 40 microns thickness of cement intervening. It is evident that roughness of this degree does undermine groups of enamel rods which results in weakened cavity margins.

Although the diamond instrument produces an over-all surface roughness of sizable dimension, Fig. 4 shows good adaptation of the amalgam. This finding was consistent with all the amalgam specimens having various degrees and types of irregularities. It appears that a good clinical technique of mixing and condensation of amalgam will result in good adaptation to cavity wall irregularities.

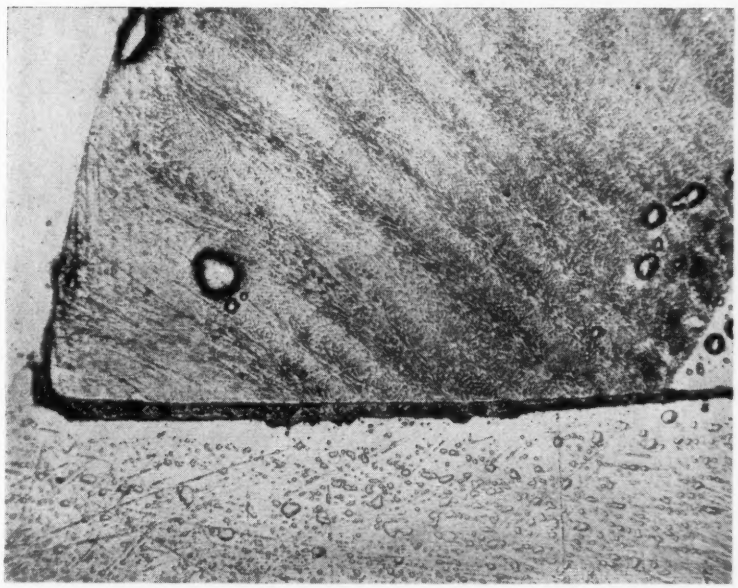

Fig. 7.—The occlusal wall of a Class V inlay. The preparation was finished with a 701 plain fissure bur.

From the casting in Fig. 5, which has been cemented to place and finished, a number of interesting observations can be made. A ridge at the axial portion of the occlusal wall resulting from the cross-cut fissure carbide can be seen. This is part of the waviness imparted to cavity walls by this instrument. The cavity wall above this ridge appears relatively smooth while the adjacent area of the casting shows minute irregularities. While the thickness of cement is in the same order as that seen in Fig. 3, note that the margin has been closed during the finishing procedure. Since enamel rods were left unsupported at this margin during cavity preparation, they have fractured as a result of the marginal manipulation.

The casting in Fig. 7 has tilted slightly during seating and has not been finished at the margins. In this section, as in Fig. 5, the cavity wall is observed to be more

Fig. 8.

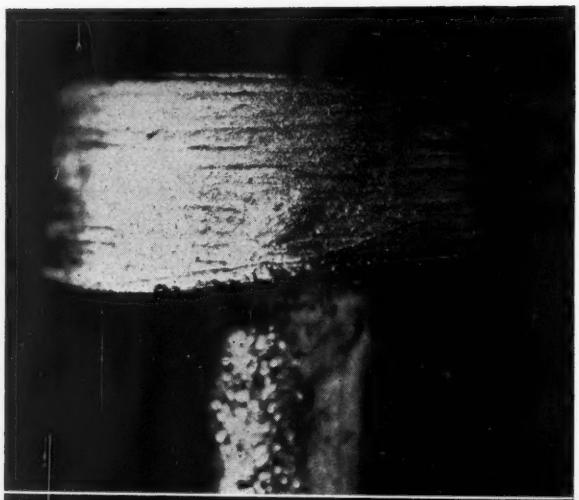

Fig. 9.

Fig. 10.

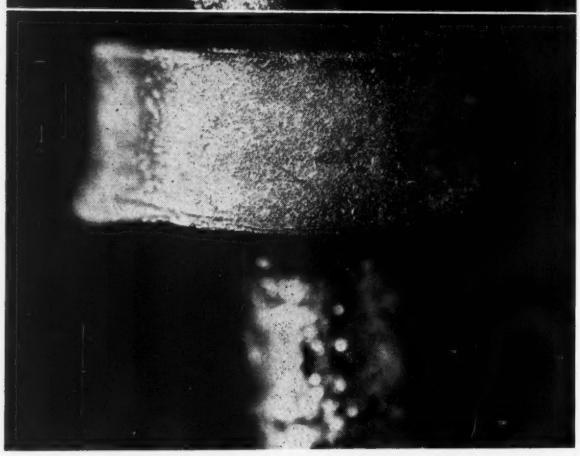

Fig. 8.—A casting for a Class V preparation on a natural tooth, finished with a medium cylindrical diamond.

Fig. 9.—A casting for a Class V preparation on a natural tooth, finished with a 701 cross-cut fissure carbide bur.

Fig. 10.—A casting for a Class V preparation on a natural tooth, finished with a 601 plain fissure steel bur.

smooth than the adjacent casting. These irregularities on the casting are the "inherent roughness factor" to be discussed later.

### CASTING COMPARISONS IN IVORINE BLOCK PREPARATIONS

The use of natural teeth presented some technical problems and did not allow a comparison to be made of castings seated in similar types of preparations and finished with various instruments. The use of Ivorine blocks for the preparation of a series of similar types of preparations allowed close control to be maintained throughout this area of the investigation.

In such a controlled study, it was first necessary to establish the effect of certain variables of the casting technique upon the roughness of the casting. The controlled water-addition technique was used since this has been shown to give reproducible results, and the amount of expansion is easily varied.

To establish basic roughness, castings were made from wax rectangles whose surfaces were developed against polished glass. A surface-active agent was applied to the patterns which were then either vacuum-invested or mechanically spatulated and hand-painted. All gold was new, of the same composition, unfluxed, and cast at a temperature of 1950° F. Roughness measurements were made on the Profi-corder.[1] The following observations were made: (1) The original W/P ratio appears to have little effect on the casting roughness in the range of 15 c.c. to 18 c.c. with 50 Gm. of investment. (2) The difference in burnout time between 1 hour and 2 hours at 875° F. has no significant effect on roughness. (3) For the heavier consistencies (15 c.c., 16 c.c., and 17 c.c.) vacuum investing, in contrast to hand painting, appears to result in a slightly smoother surface, with little difference observed with 18 c.c. in the W/P ratio. (4) Roughness was significantly greater with a different type of investment and technique (as directed by the manufacturer) than for the previous castings.

The inherent roughness of the gold inlay, due to the casting procedure using the controlled water-addition technique (Hygrotrol investment), 16 c.c. to 50 Gm. of powder, and vacuum investing, ranges up to 150 microinches (or millionths of an inch), with most values between 50 and 75 microinches. This casting procedure was used for all subsequent castings. In contrast, the machine-prepared cavities in Ivorine had wall roughnesses in the following order of magnitude:

| | |
|---|---|
| Steel cross-cut fissure | —3000 microinches |
| Carbide cross-cut fissure | —2000 microinches |
| Cylindrical diamond | —1250 microinches |
| Plain fissure | —250-375 microinches |

The castings made from wax patterns taken of these preparations had essentially the same roughness except for the plain fissure bur, where the upward range extended to 500 microinches.

The Class I and full-crown castings, made from wax patterns formed on the preparations finished with the plain fissure bur, exhibit a better seating and wall adaptation, both with and without cement, than do the more rough castings under

similar conditions (Figs. 11 and 12). A 125-pound static load was insufficient to seat completely any of the cemented Class I castings, although the "plain fissure" casting was only very slightly unseated. With the full-crown castings, a 400-pound static load was necessary to bring about the "complete" seating as might be determined with a sharp explorer.

Fig. 11.

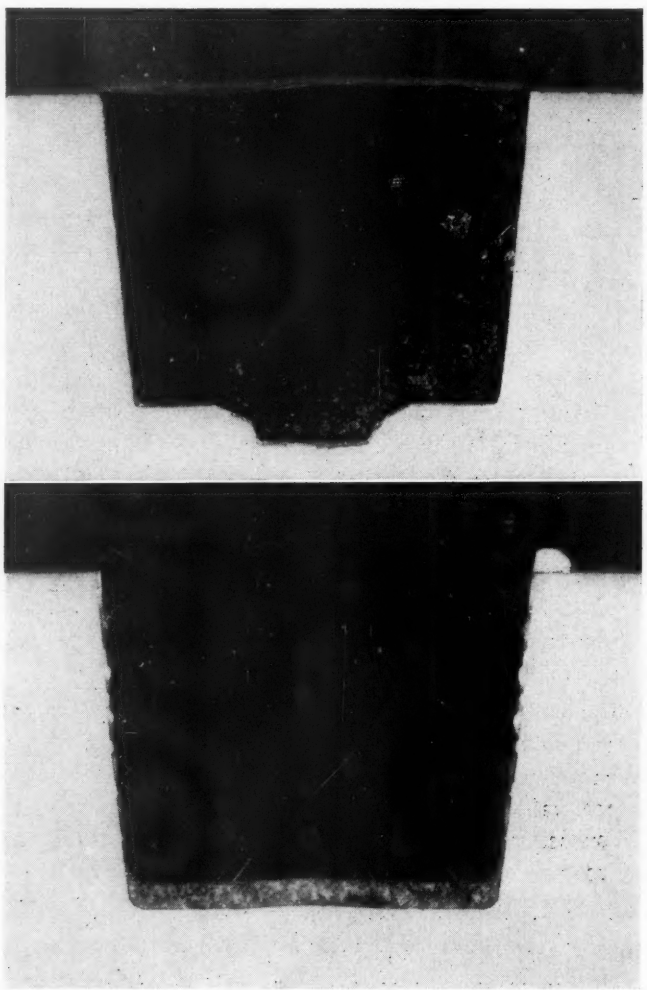

Fig. 12.

Fig. 11.—A section through a Class I casting cemented in an Ivorine preparation finished with a 601 plain fissure steel bur. A 10 per cent taper was established, and a seating force of 125 pounds was used.

Fig. 12.—A section through a Class I casting cemented in an Ivorine preparation finished with a 701 cross-cut fissure carbide bur. A 10 per cent taper was established, and a seating force of 125 pounds was used.

An examination of these sectioned restorations shows that the castings made from the diamond finished preparations, which have a roughness somewhat less than

those finished with the cross-cut fissure burs under the conditions of preparation used in this area of the study, exhibit the next best adaptation and ability to seat. This diamond roughness is an all-over, rather evenly spaced roughness (Fig. 8), as compared to the widely spaced concentric rings produced by the cross-cut fissure burs. Although this latter type of roughness is somewhat artificial due to the machine cutting of the preparation, its effect on the shearing and possible distortion of the wax and the trapping of cement presents an exaggerated, but realistic, situation.

Proper compensation for the full-crown castings was impossible with the usual method of using a hard inlay wax for the patterns. There was consistently a relatively greater expansion across the cervical portion of the casting than across the occlusal portion. Apparently the hard inlay wax at the proximo-occlusal area of the pattern tends to restrict the normal setting and hygroscopic expansion at this area, while the cervical portion has less restriction imposed. It was suggested that the continued use of the hard wax around the proximal area with a soft, less restrictive wax at the occlusal and proximo-occlusal angles would allow for a more uniform outward expansion in both occlusal and cervical areas. This proved to be true, and this technique was adhered to for this type of castings.

The Class II and VI castings showed slight wall and marginal discrepancies in adaptation. Although the two-surface castings had good axial wall and pulpal floor adaptation, there appeared to be a very slight opening at the occlusal and cervical margins, with lack of intimate contact against the corresponding wall and floor. These discrepancies may be caused by the tendency of the expansion to open the L-shaped wax pattern or the relatively large bulk of the small-sized casting. An increase in compensation appeared to decrease these errors, but there was a reduction in the retentive grasp between the isthmus and axial wall.

The Class VI castings exhibited a difference in expansion across the occlusal and cervical areas similar to that observed with the full crown. Although a change to a softer wax lessened the relatively greater cervical expansion slightly, excellent adaptation along the complete axial walls on both sides was not attained.

From a cementation standpoint, the Class II and VI castings presented no difficult problems. The ability to seat these is good, probably due to the ease of escapement for the excess cement naturally provided by the preparation.

## DISCUSSION

The various rotating dental instruments produce a wide range of roughnesses on cavity walls. It appears that the coarser roughnesses are significant from a clinical standpoint for two reasons. First, it is evident that the use of diamond instruments as well as the cross-cut fissure burs for finishing results in irregularities which tend to allow unsupported enamel rods to remain at the cavosurface margins. Second, from the attempts at seating castings in the Ivorine preparations where some qualitative comparisons of adaptation could be made, it appears that the greater the roughness, the more the casting will remain unseated.

The effect of the types of roughnesses, the all-over diamond type compared to the spaced-ridge type of the cross-cut fissure bur, may be different as is suggested

by the Ivorine preparations. The direct transfer to a clinical situation of the observations on ability of the casting to be seated may be questioned, but with the greater roughnesses some distortion of the wax pattern is inevitable. Certainly from the standpoint of cavosurface marginal strength, smoothness of cavity wall is desirable.

The ultimate smoothness of the casting appears to be a function of the investing material and casting technique rather than the cavity wall finish. This inherent casting roughness together with the irregularities of the wall itself should provide sufficient mechanical interlock for the cementing media.

It was evident from the marginal adaptation seen throughout this study that proper finishing is necessary prior to cementing. A gold, which possesses a sufficiently low yield point and high per cent elongation without detriment to the other necessary physical properties demanded by the situation, will enhance the dentist's ability to bring about a more desirable adaptation. The introduction of a cavity liner and cement will undoubtedly alter, to some degree, the previously obtained wall and marginal relations. This brings about the necessity of proper "margination" at the time of cementing before the cement becomes sufficiently set to form a layer between casting and tooth tissue. Such a layer of cement will, in time, become dissolved and will disintegrate, leaving an open margin. These procedures of finishing appear necessary even with a sound, reproducible casting technique.

## CONCLUSIONS

1. The casting procedure imparts surface irregularities to the gold which becomes an inherent roughness factor.

2. The inherent casting roughness appears to vary with the type of investment and, with lower W/P ratios, is decreased slightly by vacuum investing.

3. The wax copies cavity wall detail, but it will shear and possibly distort upon removal from undercuts produced by some rotating instruments.

4. In this study, the preparations with smoother walls had better wall and marginal adaptation than those with rougher walls. The degree of roughness, as well as the type, appears to have some significance in the ability of the casting to be seated.

5. Even the smoothest cavity walls and castings produced appear to present irregularities for the mechanical interlocking of the cementing medium.

6. The presence of cement significantly affects the ability of a Class I or full-crown casting to be seated.

7. When using the controlled water-addition casting technique, better adaptation of the lateral walls is obtained with the full crown when a softer wax is used to form the occlusal and proximo-occlusal areas, still using a hard wax on the remaining proximal areas.

8. The use of a sound casting technique does not preclude proper "margination" of the casting prior to and immediately upon cementing.

9. Amalgam may be well adapted to rather rough cavity walls when following a good clinical technique of manipulation and condensation.

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# DUAL ENGINE EQUIPMENT FOR HIGH-SPEED TECHNIQUES

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WITH THE ADVENT OF ultraspeed belt-driven equipment, the dentist is faced with the problem of changing handpieces frequently. The reason is that belt-driven equipment is still limited to contra-angle handpieces. Such equipment cannot be used for certain operations, such as polishing amalgam fillings, oral prophylaxis, powering amalgam vibrators, trimming dentures and inlays, or anything which needs cutting tools of large diameter. Although several manufacturers*

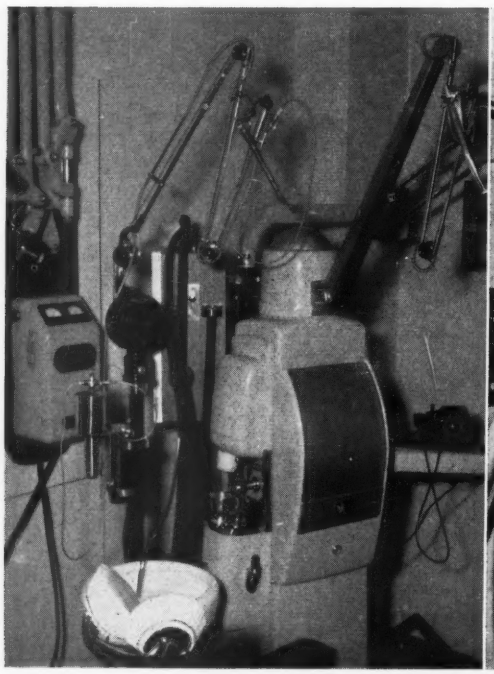

Fig. 1.

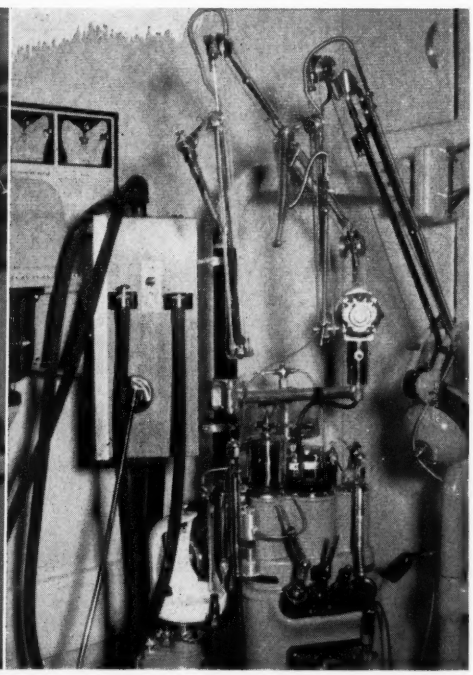

Fig. 2.

Fig. 1.—A Ritter Model H unit combined with a Fluid Air and Foredom motor. It is used with a separate Dual Control Thermex coolant attachment.

Fig. 2.—A Ritter Model E unit with Dual Control Thermex unit is combined with an Emesco engine on the operating light support. The Emesco engine has a separate Dual Control Thermex unit.

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*Densco, Chayes, and Kerr.

have friction clips available for fast changing from the Page-Chayes and Kerr superspeed angle to a straight handpiece, this procedure is still time-consuming and inconvenient because the belt tension has to be readjusted whenever a change is made. The inconvenience of handpiece changing can be overcome by various setups of dental engines. For several years, I have employed two engine setups at one chair to do comparative testing of various high-speed equipment. I have found that such arrangements are so satisfactory that each of my three operating rooms is now equipped with two engines.

There are three types of dual equipment arrangements. The first arrangement has two "unit" engines, with one on a pedestal, and uses a single foot controller with a switch to cut out the engine not in use.

One Thermex unit, or other coolant device, may be used with a cross-over connected so that both handpieces can have a coolant from the same Thermex attachment. When the coolant unit is on the unit engine, it can be arranged so that the coolant solenoid will operate for the auxiliary engine also. If desired, two Thermex units may be used, so the necessity for a cross-over connection is eliminated.

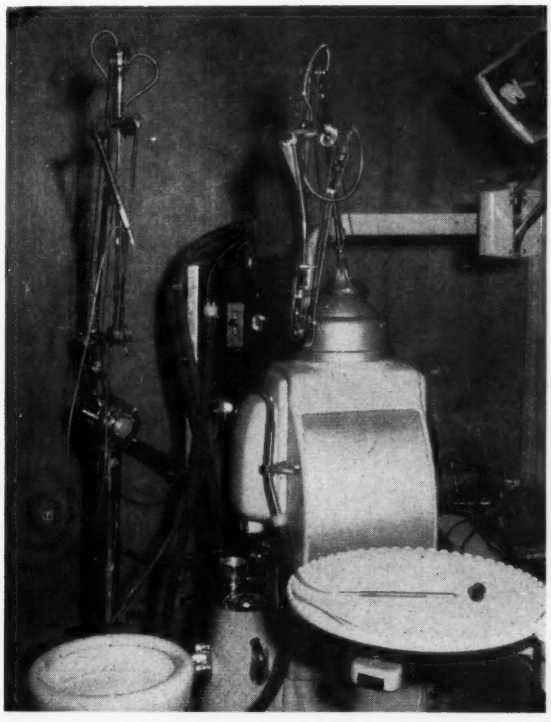

Fig. 3.—A Ritter G Unit with Tri-Jet and Emesco engine has a Dual Control Thermex unit mounted to the rear of the G unit.

The second arrangement consists of one 'unit' motor and a regular laboratory engine, such as the Emesco or Foredom, which is mounted on a pedestal beside the unit or put on a mounting arm attached to the operating light arm. This setup

Fig. 4.—A foot controller for the auxiliary engine is mounted on the top of the Roto-Seat Pedal. This arrangement makes it easy to engage the Thermex solenoid on the main unit engine when using a cross-over connection.

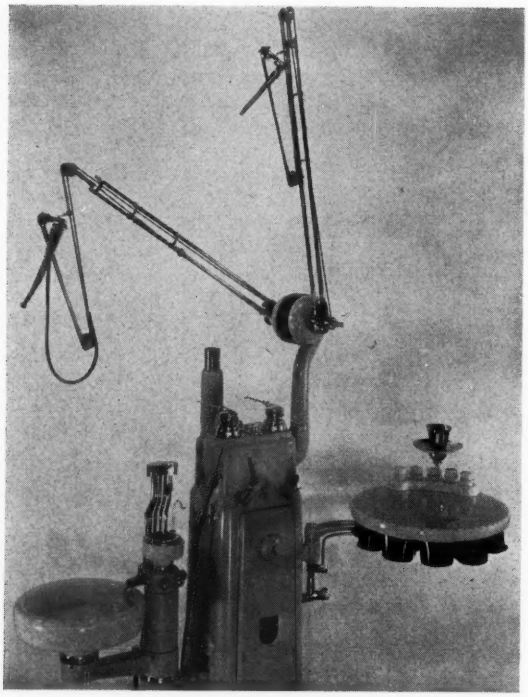

Fig. 5.—An Emda Double Arm engine mounting utilizes a single unit engine to drive two separate arms.

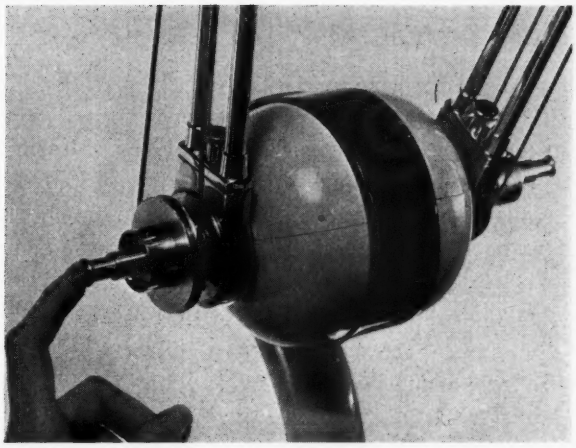

Fig. 6.—A clutch arrangement permits changing from one arm to another on the Emda Double Arm engine mounting.

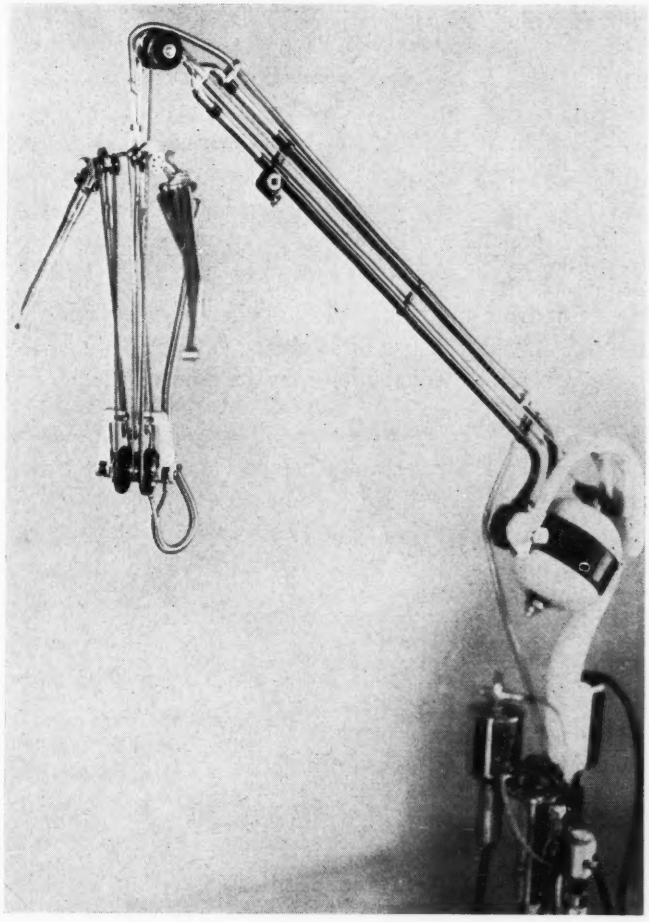

Fig. 7.—A dual arm transmission which makes the regular handpiece and the Page-Chayes handpiece available on any standard dental engine controlled by a single foot rheostat. This arrangement eliminates the need for belt changes, a second engine, and duplicate coolant equipment.

usually needs two foot controllers, and the cooling operation may be controlled the same as for the two "unit" engine arrangement.

The Foredom and Emesco engines can have a large Formica Chayes pulley mounted on it to produce a higher speed. Speeds up to 30,000 r.p.m. can be attained with this arrangement. While this arrangement is not quite as efficient as the first or third arrangement, it does make a second power source available with the minimum of expense. Figs. 1 to 4 illustrate different combinations of "unit" motors, laboratory engines, and coolant devices that are available for dental office use.

The third arrangement consists of a single "unit" engine equipped with two arms and a clutch to engage the engine arm desired. This is one of the most efficient arrangements available (Figs. 5 and 6). One foot controller and one central coolant unit is employed with separate tubing for each arm. It is necessary to have a means of cutting off the coolant to the arm which is not being used. Emda and S. S. White units have such arrangements available, but the S. S. White unit does not have a clutch. With it, the belt must be changed from the arm being used to the pulley desired whenever the setup is changed.

SUMMARY

Auxiliary engine arrangements are described by which the dentist is afforded the convenience of the immediate use of a Page-Chayes, Globe, Kerr, or other belt-driven contra-angle and a straight handpiece with a minimum of time lost in making the change.

High-speed equipment and techniques are changing so rapidly that it is necessary for the dentist to make full use of auxiliary equipment in order to avoid purchasing expensive equipment which soon may become obsolete (Fig. 7).

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# ELECTROFORMED DIE TECHNIQUE FOR RUBBER BASE IMPRESSIONS

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THE THIOKOL RUBBER BASE impression compounds have proved to be stable, accurate, elastic impression materials which make a valuable contribution in the construction of inlays, crowns, and bridges. Impressions made with these materials can be poured in stone or electroformed in copper or silver. Although stone dies are very satisfactory, some clinicians prefer to use an electroformed die as a procedure which facilitates the finish of the inlay margins. It is generally considered that the Thiokol rubber base materials can be more readily silver-plated than they can be copper-plated. The silver-plated dies so produced have a good surface and are clinically accurate. Silver[1] describes an impression technique and a procedure for a silver-plated laboratory cast with removable dies for multiple crown restorations. Copper-plated dies from individual copper band and modeling compound impressions have been widely used for many years; however, elastic impression materials, such as the Thiokol rubbers, lend themselves especially to tray impressions and to use in multiple inlay preparations. The plating of such impressions and the fabrication of laboratory casts suitable for inlay, crown, and bridgework presents some new problems. This article discusses the practical aspects of dental silver-plating and describes one method of producing a silver-plated laboratory cast with removable dies of the prepared cavities.

## SILVER-PLATING

The basic principles for silver-plating are the same as for copper-plating, and the same apparatus can be used, provided the rheostat will reduce the current into the required range. Silver-plating procedures require a lower current setting than the equivalent copper-plating procedure.

A pure silver anode is required, and a silver cyanide plating solution is used in the bath. A formula for such a solution is given by Blum and Hogaboom,[2] and a ready compounded product is available through the dental supply houses.

In silver-plating, the surface of the impression is rendered conductive to the plating solution by painting it with fine silver powder, in contrast to the colloidal graphite or copper powder used in copper-plating. Suitable silver powders are available from the dental supply houses.

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PREPARING THE IMPRESSION FOR PLATING

After removal from the mouth, Thiokol rubber base impressions should be washed with cold water to remove saliva, dried with air, and set aside for one-half to one hour to allow polymerization to proceed and full elastic properties to develop. The silver powder conductive coating is applied with a small inlay brush and dusted into the cavity and teeth areas of the impression. Powder is also applied to the interproximal papillae areas and to the gingival and mucosal areas around the teeth to be plated (Fig. 1). Excess powder is removed with a strong blast of air; care is needed to ensure that no excess powder is left in the tips of the cusps.

Where a metal tray has been used, it is convenient to cover all exposed metal with wax, and this is done best by flowing a thin layer of melted utility wax over the metal with a wax spatula. In the technique to be described, the metal tray is not used to conduct current to the areas to be plated; however, if the metal remains exposed, it will acquire a thin silver coating. This is not detrimental, but over a period of time it wastes a considerable amount of silver.

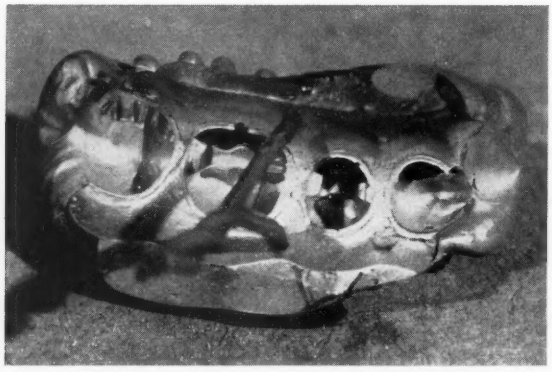

Fig. 1.—A tray impression of two cavity preparations showing the silver powder coating and two insulated conducting wires, the bared ends of which are inserted into the silvered impression on either side of the teeth with cavity preparations. The wires have been cut off short to facilitate the photography. This impression was made in a perforated metal tray with a detachable handle which has been removed prior to plating.

The plating current is conducted to the silvered impression surface by means of wires inserted into suitable points of the rubber base impression (Fig. 1). The number of wires used can be varied to suit the size of the impression, but with the type of impression usually encountered in inlay work, involving up to five teeth, two wires are normally adequate. Single strand 20-gauge copper wire with a plastic insulation is used. A three- or four-inch length of wire is cut, and the insulation is stripped from one-half inch at one end and about one-quarter of an inch at the other end. The shorter of these exposed ends is then cut obliquely with side-cutting pliers to make a sharp point which can be inserted readily into the rubber base impression. Fig. 1 shows an impression, after silvering, into which two such conducting wires have been inserted. The wires are placed on either side of the area of the impression containing the cavity preparations and far enough away from the prepared teeth to avoid any distortion. The shorter pointed end of the wire

is pushed into the rubber base impression until the insulation on the wire is flush with the impression. It is essential that the wires are placed in an area of the impression which has been painted with silver powder. After insertion, the wires are stabilized by twisting them together close to the impression, and also the ends of the bared copper wires are twisted together to facilitate their attachment to the plating electrode of the plating bath.

Fig. 2.

Fig. 3.

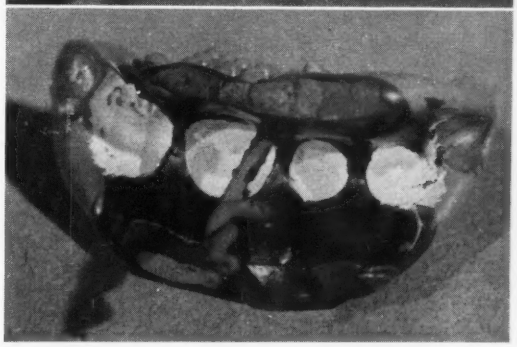

Fig. 2.—The initial thin coating of silver at the end of about five minutes of plating.
Fig. 3.—A thin layer of melted utility wax has been flowed over the initial silver coat, leaving only the teeth areas exposed to further plating.

## PLATING THE IMPRESSION

After the surface of the impression is silvered and the conducting wires are attached, the impression is ready for introduction into the bath. Electrolyte is placed in the deeper parts of the impression by means of a small pipette in order to avoid the retention of air bubbles. The impression is then immersed in the bath and connected to the electrode. For a tray type of impression, where some of the surrounding mucosal area of the impression is plated, the current should be calculated on the basis of 10 Ma. per tooth. For single impressions in a copper band, where no adjacent mucosa is involved, calculate the current on the basis of 5-7 Ma. per impression according to the size of tooth involved. Too high a current

setting will produce gas bubbles at the surface of the impression and the formation of a powdery deposit of silver. A lower setting will produce a satisfactory result, but it will take longer to build up the necessary thickness. With the values suggested, an adequate thickness of silver will be deposited in 8-10 hours.

The deposition of silver occurs rapidly over the entire surface of the silvered area, and at the end of five minutes a complete covering should be attained; any

Fig. 4.

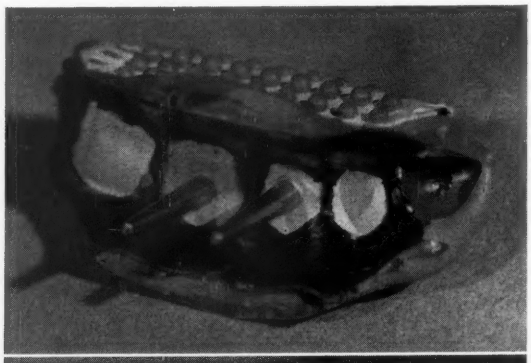

Fig. 5.

Fig. 6.

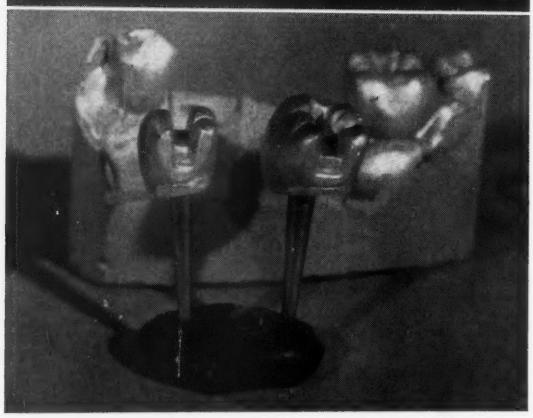

Fig. 4.—After complete plating of the impression, stone is poured into the impressions of the prepared teeth and dowel pins are inserted.

Fig. 5.—A cast obtained after boxing the impression seen in Fig. 4 and pouring in stone. The dies of the prepared teeth are removable.

Fig. 6.—A laboratory cast with silver teeth and a stone base with the dies of the prepared teeth removed.

areas not then plated need to be repainted with silver powder. This is done by removing the impression, washing it with water, drying it thoroughly with air, and touching up the deficient areas with a brush. This repainting is rarely required, and it is usual for the entire impression to plate over rapidly and completely. At the end of the first five minutes of plating, when the impression is completely covered, the impression is removed from the bath, washed in water, and dried thoroughly with air (Fig. 2). Melted utility wax is now run over those areas which are not to be plated; this should cover all mucosal areas, and special care is directed to waxing neatly over the interdental papillae areas between the preparations. In this way, the teeth containing preparations and those immediately adjacent are left exposed to the action of the plating bath (Fig. 3); the thin layer of silver under the wax serves to ensure good conduction of current to all the teeth and to the formation of an even deposit. After the waxing is completed, the impression is returned to the bath as in the first immersion and left for the required time.

## POURING THE CAST INTO THE PLATED IMPRESSION

When it is removed from the plating bath, the impression is washed in water and dried with air. Stone is poured into the impression in two stages. The stone is vibrated into the plated impressions of the teeth in which cavities have been prepared (Fig. 4), and a dowel pin is inserted into each prepared tooth. The knurled end of the dowel is completely immersed in the stone, and the pins are arranged to be parallel to each other and in the line of the long axis of the tooth. After the stone has set, any irregular areas are trimmed and then the pins and the stone surface are coated with a separating solution or a thin smear of petroleum jelly. The impression is boxed with wax and stone is poured into it. When this second pour of stone is set, the boxing wax and the rubber impression are removed, exposing the silver-plated cast (Fig. 5). Any remaining thin silver flash between the teeth is severed with a sharp scalpel or fine fret saw. The teeth containing the preparations can be pulled from the base complete with the dowel pins and can be returned readily to place (Fig. 6). Any rough edges on the tooth dies can be disked with paper disks; special care should be directed to trimming the areas approximating the cervical margins of preparations.

## SUMMARY

The principles of plating rubber base impressions with silver are discussed in relation to current strength and time of immersion. A method of producing a silver-plated laboratory cast with removable tooth dies is described.

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# PRODUCTION AND USE OF INDIVIDUAL MODELS OF TEETH AS INSTRUCTIONAL AIDS

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THE VALUE OF MODELS AS visual aids in teaching has been well established. In clinics on restorative dentistry and oral anatomy, and in courses in these subjects, replicas of the natural teeth have merit, particularly if they are morphologically accurate.

By constant study, students of dental anatomy in the profession have come to recognize the true anatomic form of teeth. Their reproductions of the teeth have not always been accurate in proportion or fine detail. In recent years, however, adherence to anatomic form of teeth in models thereof has been much more strict (Fig. 1). It would be impossible to list all of those who have contributed to the present knowledge and understanding of the morphology of human teeth, for many would be omitted inadvertently from such a roll. Certainly they merit recognition for the diligent application of their gradually acquired knowledge of dental anatomy and functional development of teeth.

In recent years, particularly useful models were developed by E. M. Jones and H. Linek at the University of Southern California and F. H. Pratt at the University of Washington. Reproductions of teeth were made in normal size, 1½ times normal size by linear measurement, 2½ times normal, and 6 times normal (Fig. 2). As a further development, to facilitate studies of cavity and abutment preparations, these workers found a satisfactory means of producing the 6-dimensional models in two colors—an inner core of buff-colored plaster, which duplicated the form of the dentine of the crown, and a surface layer of white plaster, which duplicated in form and thickness the enamel portion of the tooth crown (Fig. 3).

Further refinements in the anatomic form of these models have been made by Pratt and Schroeter at the University of Washington. The individual teeth have been reviewed with particular attention being given to the relationship of anatomic form to masticating and supportive function.

The present models facilitate the teaching of fundamentals of cavity preparations and the translation of these basic principles to the natural teeth without having to make compensation for an incorrect form, as has been necessary so often in the former enlarged models (Fig. 4). The two-tone models are of special value to teach proportionate depths for cavity preparations and to familiarize the student

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with the usual location of the boundaries of the dentine and with the varying thicknesses of enamel.

Formerly these models were reproduced in sectional compound or plaster molds. The procedure was much simplified when elastic materials, such as Nuplamold,* became available (Fig. 5). The fabrication of two-tone models necessi-

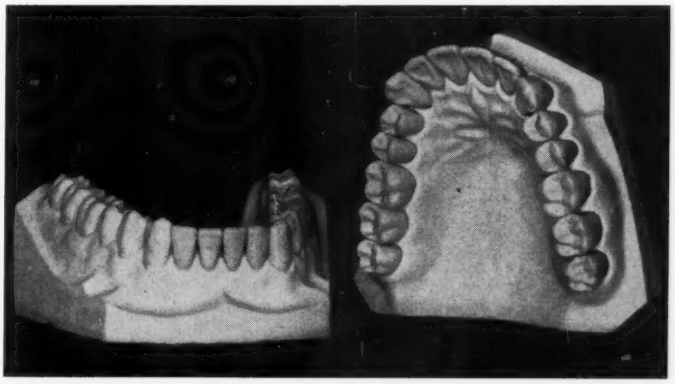

Fig. 1.—Models of maxillary and mandibular teeth, 1½ times average size, which are accurate in morphology and anatomic detail.

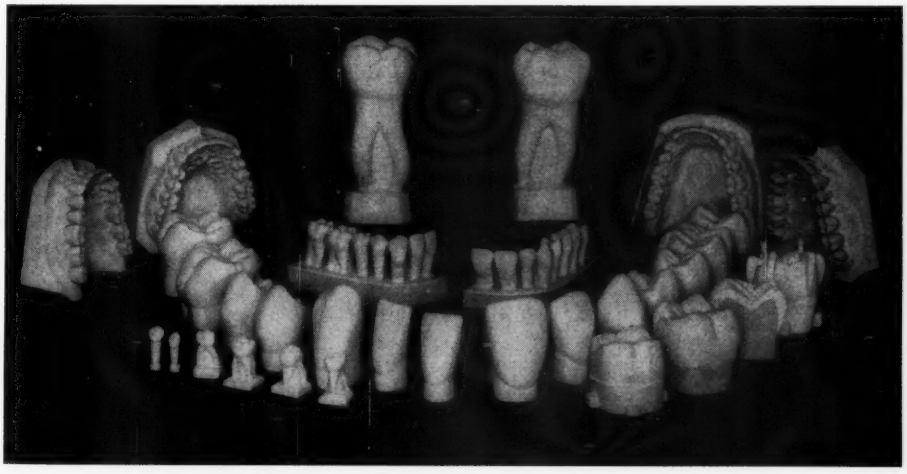

Fig. 2.—Various sizes of proportionately accurate plaster reproductions of teeth, ranging from life-size to 6 times average life-size.

tates the use of two elastic molds, one for the yellow dentine core and one for the white outer or enamel portion. The yellow core is poured first, and, after it is set, the "enamel" mold is filled with white plaster and the hardened core is positioned

*Available from New Plastic Corporation, 1017 North Sycamore Ave., Hollywood 38, California.

Fig. 3.

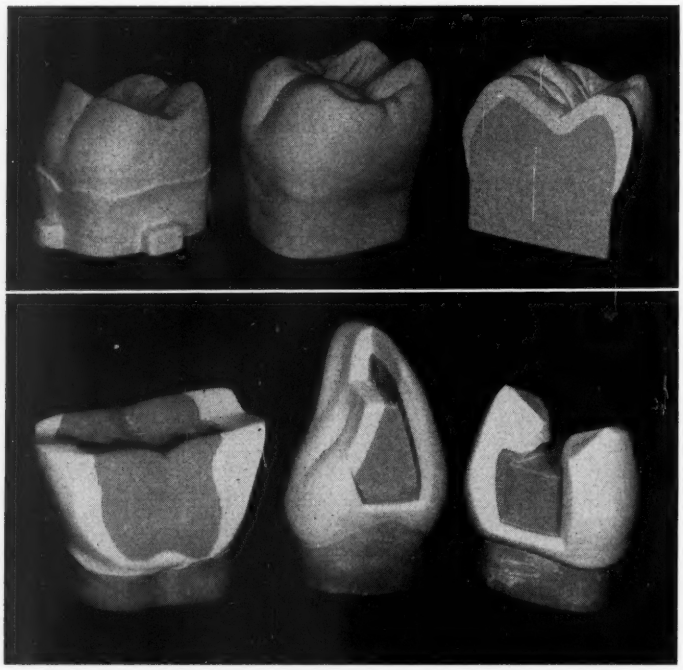

Fig. 4.

Fig. 3.—Two-tone, 6 times average life-size, reproductions of teeth. *Left,* dentine core of buff-colored plaster. *Center,* completed model with surface of white plaster to simulate enamel of tooth. *Right,* model sectioned to illustrate variable thickness of enamel.

Fig. 4.—Showing the value of two-tone models to illustrate preparations in teeth. *Left,* occlusal and buccal gross reduction of a molar for preparation for a full veneer crown. *Center,* Class IV preparation for a gold inlay in a maxillary incisor. *Right,* preparation for a gold inlay, showing detail of cavity form.

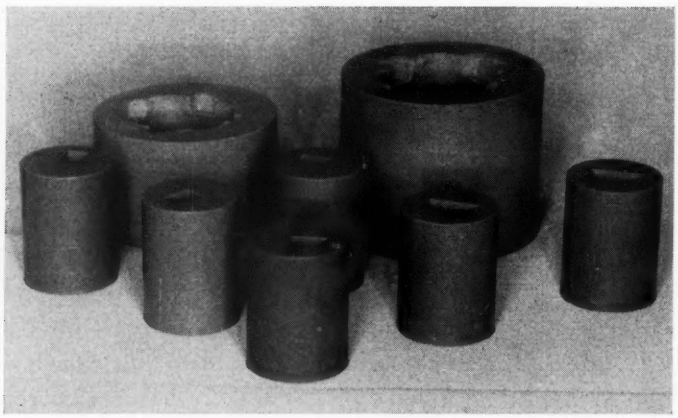

Fig. 5.—Elastic molds for various sizes of models. *Left rear,* mold for core of a two-tone model. *Right rear,* mold for second pouring of a two-tone model.

into it. The base of the model must have dovetail projections on four sides. These serve as keyways for positioning the core accurately into the enamel mold. The projections are trimmed off, and the cemento-enamel junction usually needs minor finishing after the model has been separated from the mold.

The models need to be treated so that they are easier to work upon and so they may resist soiling. It has been found that they can be so treated by impregnating them with stearic acid or paraffin. The procedure is as follows: The stearic acid or the paraffin is melted in a double boiler, and the dry models are soaked in it until the wax has penetrated the entire model. Then they are removed from the bath and wiped individually to eliminate surplus wax which would accumulate in the pits and grooves.

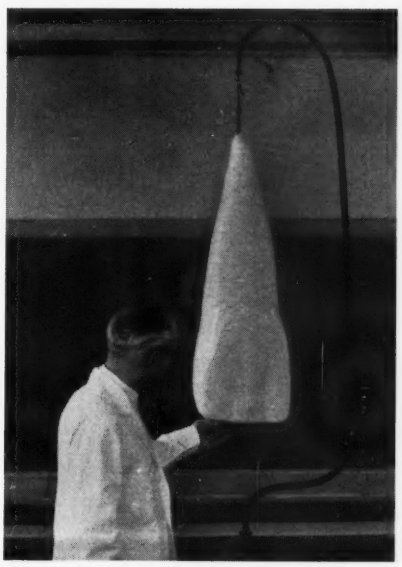

Fig. 6.—Thirty-six times life-size model of a maxillary incisor, accurate in detail and proportioning.

Occasionally, it is desirable to have preparations made before the plaster is treated and to impregnate or finish the model afterwards. In such instances, protection of the surface of the prepared model is secured rather readily by immersing it in a liquid soap solution for a maximum period of 15 minutes (prolonged immersion results in a roughened surface). Some prefer to have the solution hot during the immersion period. When the models are removed and drained, they are polished to a luster by buffing with a soft cloth.

### DISPLAY MODELS

For some display models, delineation of the dentine and enamel is not required, and an enameled surface is preferred. In such cases, the model is made entirely of white plaster and is not impregnated or treated, but it is simply well dried. Then

a coat of clear lacquer* is applied, followed by one or two coats of white or cream enamel.

For demonstrations in the classroom, 36-dimension models of a maxillary central incisors and cuspids have been constructed (Fig. 6). For these models, a frame is formed of 10-gauge galvanized wire, soldered where necessary. The interior is

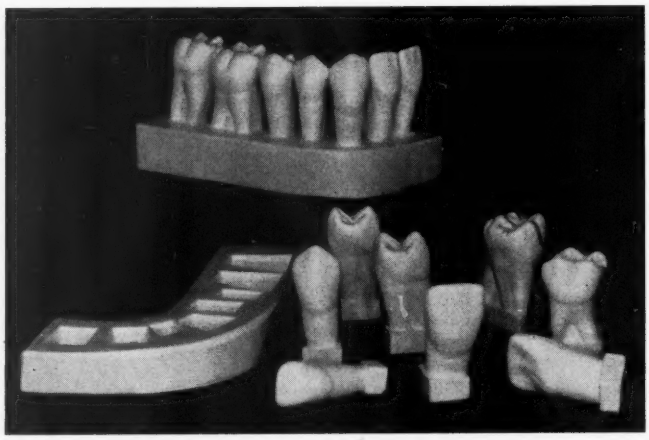

Fig. 7.—Individual 2½ times average-size models of teeth and bases in which they are set to illustrate the typical alignment.

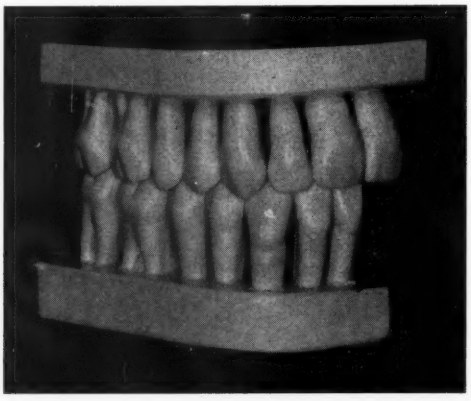

Fig. 8.—Two and one-half times average-size models of teeth, assembled in their respective bases, and approximated to illustrate the functional form.

tightly packed with crumpled newsprint. The entire frame is then covered with papier-maché or asbestos fibers mixed with wallpaper paste. The detailed anatomic form is thus developed. Before the work is completely dry, several coats of spackle are applied with a brush until a perfectly smooth surface is obtained. Minor blemishes are removed with sandpaper, and the model is allowed to dry for several weeks. After a coating with a plaster sealer, the model is painted with enamel.

*Synalac Clear Sanding Sealer, #7782, manufactured by W. P. Fuller and Company.

## USES FOR MODELS

What are the uses for the different sizes of these models? For clinics and display models, the 6-dimension replica is of greater value than are the other sizes. On the other hand, students can learn just as well, if not better, by first working on a less magnified model, such as one of 2½-dimension. It is large enough so that details may be impressed on the student, yet small enough so that quantities can be made readily. A set of these may be mounted in a base to show proximal relationships and function with the teeth of the opposing arch (Figs. 7 and 8).

For those who prefer working on the 1½-dimension models, it has been found that Ivorine or acrylic resin models are more satisfactory than are those of plaster. These are secured through manufacturers of dental models, or flexible molds may be used to make models of acrylic resin. Models of natural size are available in various materials, but few are accurate in their morphologic detail. Natural extracted teeth are useful, of course, in conjunction with the enlarged reproductions.

Each size and type of model has its advantages. The important thing is that the greater accuracy it possesses the more value it has for the clinician, the teacher, and the student in conveying with clarity the principles of technique or morphology under consideration.

University of Washington
School of Dentistry
Seattle 5, Wash.

## *CLEFT PALATE PROSTHESIS*

# PROSTHETIC CORRECTION OF A SEVERE ACQUIRED CLEFT PALATE

ALEX FOX, D.D.S.*
*Springfield, Mass.*

THE TREATMENT OF ACQUIRED clefts of the hard and soft palate requires considerable ingenuity on the part of the prosthodontist. However, the techniques which are in common use in dental practice are readily adapted to the treatment of these patients.

Oral examination of a 37-year-old white man revealed a complete absence of the soft palate and destruction of the hard palate so that only a rim of alveolar bone remained on the lingual side of the teeth (Fig. 1). The alveolar bone covering the lingual roots of the molar teeth was missing, and the roots were exposed nearly to their apices. The mouth was free of lesions other than the missing tissues.

The patient experienced difficulty in opening the mouth due to a contraction scar of the lip commissure on the right side.

The patient's major complaint was the speech defect, similar to the nasality of a person with a congenital cleft palate. The passage of food and liquids into the nasopharynx was a decided annoyance.

The construction of an obturator similar to that used for a congenital cleft was decided upon. Fortunately, the patient presented a complete complement of teeth which, after some restorative dental treatment, afforded excellent retention for the extensive appliance.

### TECHNIQUE

Impressions were made of the maxillary dental arch and the defect in the palate in hydrocolloid. The defect of the palate was built up in wax on the cast to simulate a palate of normal contour. A single thickness shellac baseplate was adapted on the cast in the hard palate area up to the teeth. In the soft palate area, the baseplate was extended laterally 2 to 3 mm. beyond the region of cleft, and it was extended distally to the place where the soft palate would end normally.

The baseplate was carried to the mouth after the portion in the region of the soft palate was heated to soften it. The remnants of the soft palate were allowed

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*Lecturer in Prosthetic Dentistry, Tufts University Cleft Palate Institute, Boston, Mass.

to reposition the baseplate until they were comfortably in repose. This repositioning required several trials for final correction in order to make sure that the swallowing action did not "kick" the baseplate down.

The baseplate was returned to the cast, and it showed a considerable change in the soft palate portion which had been distorted by the pressure of the original impression material. The wax in the region of the defect was removed from the cast, and a soft mix of stone was poured into that space. The baseplate was placed on the cast and over the new mix of stone in the space of the defect and pushed gently into place. The excess stone that squeezed out was trimmed away, and the remainder of the stone was allowed to set. This procedure provided a working cast for the palatal casting with the remaining anatomic structures in their proper positions.

Fig. 1.—The acquired cleft has caused complete loss of the soft palate and almost total destruction of the hard palate.

## GOLD CASTING

A gold casting was designed to cover the entire hard and soft palate areas as well as over the surfaces which were missing. Since there was so little of the hard palate remaining, the body of the casting was carried directly up to the height of the survey line on the lingual surfaces of the bicuspid and molar teeth. This tended to prevent food from passing into the nasal cavity. In the soft palate, the casting is extended laterally 3 mm. beyond the margins of the cleft to seal it.

For retention, all of the teeth that could be clasped were used. Rest preparations were provided on the bicuspids and second molars, and a slice was made between the first and second bicuspids on both sides. A strut bar was run distal to the second molar onto the buccal tissues to the space between the first and second bicuspids and then back between these teeth. Bar clasp arms were run off of the strut bar and run into all available buccal undercuts of the eight teeth used (Fig. 2). This provided a maximum retention for the extensive appliance. Gold was used because of its better resilience, accuracy of casting, and its ability to enter undercuts further for better retention.

When the casting was completed, it was tried in the mouth for retention and stability and particularly to note any impingement on the soft palate or tendency for displacement during swallowing. When these factors proved satisfactory, a 14-gauge triangular-shaped wire loop was soldered to the nasal side of the casting

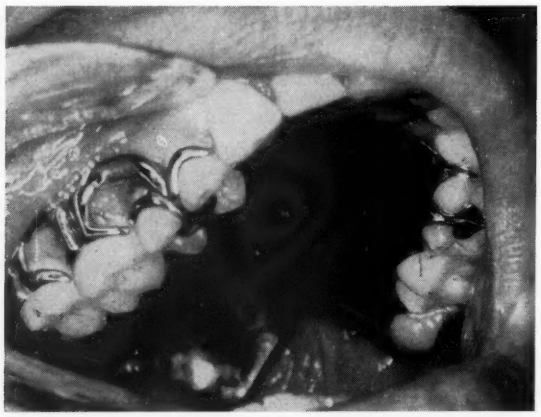
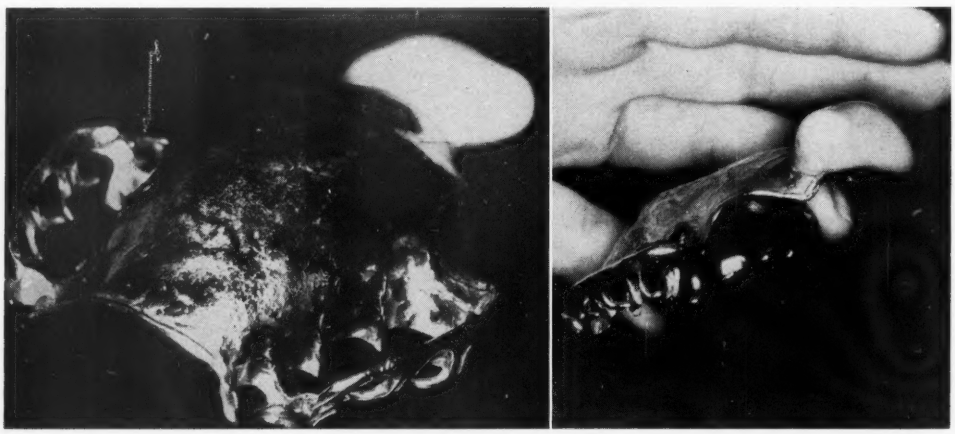


Fig. 2.—The gold casting covers the entire hard palate and the area of the missing soft palate. Note the bar clasp arms which are attached to the strut bar for retention.



*A.* *B.*

Fig. 3.—*A*, The obturator bulb is trimmed to the correct size by head movements, swallowing, and hand carving. When the patient talks or swallows, a complete closure between the pharynx and the "bulb" should be made. *B*, Note the depression on the "bulb" produced by the atlas.

in the area of the uvula. The base of the triangular wire extended upward and backward into the nasopharynx and was considerably smaller than this space. This triangular wire loop was to provide retention for the attachment of the "bulb" or obturator portion of the appliance.

THE OBTURATOR

To make the impression, a bulk of modeling compound was attached to the wire loop and allowed to harden. Then a covering of carding wax was added to the modeling compound in an amount which approximately filled the opening into the nasopharynx from side to side and which extended back to the posterior pharyngeal wall. The patient was directed to tip the head forward onto the chest, and an impression of the posterior pharyngeal wall became evident in the wax. There is usually a marked depression in the center of the back end of the mass of wax. This is produced by the tubercle of the atlas. This depression represents the posterior inferior border of the "bulb."

The patient was directed to go through the swallowing motions while turning the head from right to left as well as having it in the forward position. Planes in the wax will become evident as they are cut by the posterior pillars of the fauces when they constrict toward the midline. These planes are further developed by the hand carving and smoothing of the "bulb." When finished, the bulb may appear to be slightly small for the space it is to fill. However, when the patient talks or swallows, the constriction of the pharynx will make a complete closure (Fig. 3).

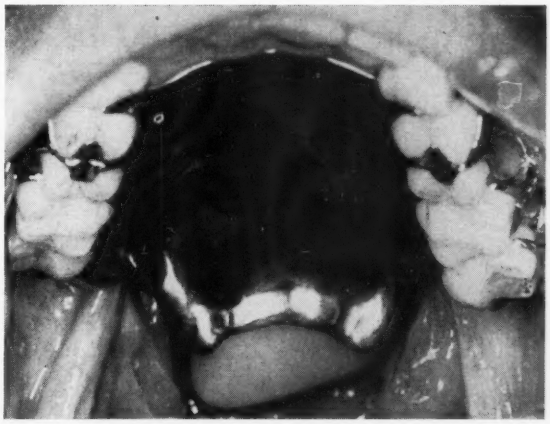


Fig. 4.—The completed appliance is in place in the patient's mouth. Note the relation of the lateral walls of the cleft to the "bulb."

When the patient stands erect with the head in a normal position, and with the mouth open, the posterior tonsillar pillars should glide freely under the bulb when the patient swallows or gags. When the patient bends over, as if to tie a shoe lace, the "bulb" should not impinge too tightly on the tubercle of the atlas. If the soft tissue is displaced at this point, a sore spot will develop.

This technique places the "bulb" in the pharynx in such a position as to provide excellent closure of the oronasal opening in swallowing or talking, and the bulb does not interfere with the dorsum of the tongue. This technique also provides a smooth, nonirritating surface of the "bulb" or obturator. It avoids the lumpy "bulbs" which result from having only the muscle carving evident without

any additional hand carving and smoothing. The "bulb" is processed in acrylic resin, and it may be worn this way or converted into a hollow gold casting after the patient has used it several days and no irritation occurs.

The completed appliance restored the voice immediately to normal. It also enabled the patient to take food and liquids with no further inconvenience (Fig. 4).

A similar appliance is used for patients with a congenital cleft palate. However, these people require speech therapy to teach them how to use the appliance after it is inserted. Also, they must be taught to correct the many faulty tongue, lip, and nose habits that they had developed previously to compensate for the leakage of air into the nasopharynx.

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1. Fitz-Gibbon, J. J.: The Correction of Congenital Cleft Palate by Appliances, D. Items Interest **45**:711-718, 1923.
2. Fitz-Gibbon, J. J.: Prosthodontist to Orthodontist, Int. J. Orthodontia **23**:337, 1937.
3. Fitz-Gibbon, J. J.: Responsibility Dentistry Must Assume in Treatment of the Oral Cripple, Am. J. Orthodont. & Oral Surg. **28**:39-48, 1942.

130 Maple St.
Springfield, Mass.

## SIXTH ANNUAL ESSAY CONTEST

*Sponsored by*
THE AMERICAN DENTURE SOCIETY

Prizes will be awarded to the two senior dental students who submit the best essays on prosthetic dentistry in the sixth annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

### RULES

1. The contest is open to all senior dental students of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college conduct its own contest to determine the two best essays submitted by members of its senior class.)
3. Essays are to be on some phase of prosthetic dentistry and limited to a maximum of 3,000 words.
4. Essays must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY and must be prepared in a form which is satisfactory to the requirements of that Journal.
5. The original essay and one copy must be submitted for the use of the judges.
6. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. Paragraphs must be indicated clearly by indentations, and generous margins must be allowed on each page.
7. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY, if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the figure number and the legend typed on the paper beneath the illustration.
8. The form and punctuation of references must conform to the style used in the JOURNAL OF PROSTHETIC DENTISTRY. The references must be keyed to the text material.
9. The permanent address of the author must be at the end of the reference page.
10. The student has a free range in the choice of topics within the broad interpretation of prosthetic dentistry.

11. Essays will be judged on the basis of subject matter, neatness, composition, spelling, illustrations, charts and tables, number and accuracy of references, continuity of thought, and length of the essay.
12. The judges of the contest are members of a committee of The American Denture Society. The decision of the judges is final.
13. Essays are to become the property of The American Denture Society. None will be returned.
14. All essays submitted in the contest shall be clearly marked "Contest Essay" and shall be accompanied by a letter from the professor of prosthetic dentistry and/or the dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
15. Essays must be postmarked on or before July 15, 1958 and sent to:

Dr. Victor L. Steffel
Secretary, American Denture Society
College of Dentistry, Ohio State University
Columbus 10, Ohio

# *READERS' ROUND TABLE*

STOCKHOLM, SWEDEN

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In your Journal [J. PROS. DEN. 7:798, 1957] of November, 1957, is an article by Dr. Isaih Lew of 200 Central Park South, New York, dealing with the so-called button-technique under the heading of "Mucosal Inserts—A Progress Report."

Dr. Lew appears to have no references in this connection apart from his own and Dr. Kestenbaum's article in the *Dental Digest* [59:298-300, 1953]. I have not read that article. It may well be that it refers to the actual pioneers of the button-technique, but still I feel, for ethical reasons, that I would ask you to publish this present letter for the purpose of full information.

The button-technique was invented in the early forties by a Swedish dentist. According to his wish, the invention was taken up immediately for further development, research, and testing by one of the most well-known specialists in Sweden, Dr. Hans Nordgren. The amount of installations increased rapidly, and evidently Dr. Nordgren disposed of the most extensive file of material to be found in this line—already in 1953—and included those details which are obviously meant to cover the heading of Dr. Lew's recent article.

When, during a recent meeting of colleagues, this matter was mentioned, attention was drawn to the fact that early in 1953, and evidently before Dr. Lew and Dr. Kestenbaum's first article was published, Dr. Nordgren lectured upon the method just at the said gentlemen's clinic during a personal visit in New York.

Illis quorum meruere labores.

Yours sincerely,

R. PERSSON

LOUISVILLE, KENTUCKY

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In January of this year, I received a letter from Dr. L. George Parry, a paragraph of which says: "Yesterday I spent part of the time to catch up on the literature and after several hours of reading I threw it aside, somewhat disgusted and composed the enclosed lines."

We have a very serious research group in Louisville, the name of which is The Louisville Dental Research Group. We have at the present time eight members. We have recently constructed three complete upper and lower dentures using cast aluminum bases, all made from the same casts. From there, we proceeded with construction of the dentures on three different instruments, Tripod, Transograph, and Gnatholator. At our last meeting, the Gnatholator member presented his case. The patient was present, and the dentures were carefully examined, checked, tested, scrutinized, and found to be excellent.

The Gnatholator technique was then presented using slides as well as the instrument itself. In his opening remarks, the clinician stated that, "This is a long, tedious, difficult and not-practical technique," but said he, "that is beside the point. The fundamentals are, in my opinion, correct and I believe in them." Let us assume he is correct in all his statements. The challenge thrown down to dentistry, as I see it, is to so simplify the technique, without sacrificing any fundamentals, as to make it practical for all dentists.

Now back to Dr. Parry. I think he was overwhelmed by the complicated techniques to the extent that he threw down his literature somewhat in disgust. I think the challenge to dentistry is plain. Can we simplify without sacrifice of principle?

Sincerely yours,

ELAM HARRIS, D.D.S.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

## A PRAYER FOR PRACTICAL PROSTHODONTISTS

Lord, bless us with some inner sight
To forget that we are erudite,
To weigh the facts, to see the light,
To know the truth, to do the right,
And help us in our daily plight.

Some know not what of Gnathoscope
But all know with what each must cope,
So give us judgment in our hope
That we may stay within our scope,
And not lose all in one fell swoop.

Ours is not a science pure.
Ours is not an art secure,
So keep us then from being sure
Like those whose thought is immature.

We pray that we can always see
The need and the necessity
Of thoughtful practicality
To meet the problem sensibly,
And not forget humanity.

So grant us then the sense to name
The method that will win the game,
And give us courage to place blame
On our errors without shame:
We ask all this in Thy Great Name.

Amen

L. GEORGE PARRY, D.D.S.

JERSEY CITY, N. J.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

Your critique on Dr. Hoffman's article [J. PROS. DEN. 8:205, 1958] in the March issue of THE JOURNAL OF PROSTHETIC DENTISTRY puzzled me. I have been using the Transograph for several months and reading with great care all the pros and cons which are just beginning to appear in the literature.

When Dr. Trapozzano's comments were printed following Dr. Schweitzer's article, the misstatements he made indicated to me that he had never used the instrument nor tried to understand the underlying concepts. I wondered if that were not true when I read your critique.

When you state that, "A 'mechanical equivalent' can be achieved more consistently by solid guidances than by the flexibility of the parts of the instrument," I believe you miss the significance of the principle of the split axis which is built into the Transograph. By capturing the rotational axal centers of the condyles and transferring them accurately to the instrument, any movements made by the instrument become mechanical equivalents of the mandibular movements made by the subject. Thus, any deviations in the vertical, horizontal or sagittal planes which occur in mandibular movements are duplicated in the instrument, since the axes represent the controls over these movements. It is for this reason that we are able to register hinge bites at openings of from 2 to 15 mm., and the instrument will accept them all perfectly.

In another article in the same JOURNAL, Dr. Sears attacks orthodoxy and the voice of authority as hampering the pioneer thinker. I believe his point is well taken. It is certainly true that the principles of occlusion taught in the dental schools have not changed much in the last forty years. The quantity of literature on this subject confirms the suspicion that perhaps these principles have not provided for clinical success to any great extent. It would seem that a new approach is needed and that old concepts should be carefully re-examined.

It is to your credit that as editor of the leading publication in its field of dentistry you have seen fit to print subject matter pertaining to Transographics. I shall continue to look forward to more articles like those by Dr. Schweitzer and Dr. Hoffman.

Very truly yours,

MORTIMER C. DAVIS, D.D.S.

NEWPORT BEACH, CALIF.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In regard to your remarks in "Through the Eyes of the Editor" [J. PROS. DEN. 8:205, 1958] of March, 1958, in discussion of the article by Edward J. Hoffman: It seems more argumentative than constructive to say dogmatically that, "A 'mechanical equivalent' can be achieved more consistently by solid guidances than by the flexibility of the parts of the instrument." The fact is that the Transograph does duplicate functional movements and can prove that it does so accurately. It may be difficult to understand why it does so but the laboratory proof does not bear out your assertion. In the Department of Operative Dentistry at the University of Southern California, we have made comparative mountings of models of clinic patients on various instruments and have found the Transograph more capable of duplicating functional movement.

Sincerely,

WILLIAM O. MUFF, D.D.S.

# *NEWS AND NOTES*

## MEETINGS

Pacific Coast Society of Prosthodontists, Timberline Lodge, Government Camp, Oregon, July 31 to Aug. 2, 1958.

International Dental Federation, Brussels, Aug. 27 to Sept. 4, 1958. Dr. Marcel Joachim LSD, 67, rue de Trèves, Brussels, Belgium, will send all necessary information together with forms for registration and reservation of accommodation upon request.

American Denture Society, Adolphus Hotel, Dallas, Texas, Nov. 7 and 8, 1958.

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## ANNOUNCEMENTS

Reprints of the "Glossary of Prosthodontic Terms" will become available again shortly after May 1. Please note that orders will be filled only when accompanied by payment.

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Temple University School of Dentistry announces the following postgraduate courses:

Endodontics—Immediate Root Resection, Dr. Louis I. Grossman and Dr. Leonard Parris, June 3 to 7, 1958.

The Porcelain Jacket Crown, Dr. Joseph Ewing, June 11, 12, 18, 19, and 25, 1958.

For further information and application, write to Dr. Louis Herman, Postgraduate Division, Temple University School of Dentistry, 3223 North Broad Street, Philadelphia 40, Pa.

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Tufts University School of Dental Medicine announces the following postgraduate refresher course:

Complete Denture Prosthesis, Dr. Irving Hardy, June 2 to 6, 1958.

For further information, write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

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The Division of Graduate and Postgraduate Studies of Tufts University School of Dental Medicine will conduct the Ninth Annual Berkshire Conference in Oral Pathology and Periodontology at Eastover in Lenox, Mass., June 15 to 19, 1958.

For further information and application, write to Ninth Annual Berkshire Conference, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston 11, Mass.

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Indiana University, School of Dentistry announces a course for technicians in Laboratory Phases of Fixed Bridge Construction, July 28 through Aug. 1, 1958.

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The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Twin Wire Mechanism, Dr. Joseph E. Johnson, June 2 to 6, 1958.

Endodontics—Immediate Root Resection, Dr. Louis I. Grossman, Dr. Leonard Parris and Associates, June 2 to 7, 1958.

Second International Conference on Endodontics, June 22 to 27, 1958.

Endodontics Teachers' Course, Dr. Louis I. Grossman and Associates, Sept. 8 to 10, 1958.

For further information or application, write to Director, Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce St., Philadelphia 4, Pa.

The University of Santo Domingo, College of Dentistry announces the following three courses to be given in conjunction with the University of Alabama School of Dentistry:

Oral Medicine, Dr. E. Cheraskin, July 7 to 11, 1958.

Prosthodontics, Dr. William L. McCracken, Aug. 4 to 8, 1958.

Oral Surgery, Dr. René A. Puig Bentz, Sept. 1 to 5, 1958.

For further information, write to Dr. Fernando Camino Cestero, Dean, University of Santo Domingo, College of Dentistry, Ciudad Trujillo, Dominican Republic.

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Next Meeting: School of Dental and Oral Surgery, Columbia University, New York, N. Y., Dec. 6 and 7, 1958.